OCT 2 1919

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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SESSION 1919-19.
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Full prospectuses may be obtained on application to the Secretaries of the respective institutions.

JAMES BIRD, A 158
Clerk of the London County Council.

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Goldsmiths' College, NEW CROSS, S.E.

The NEW SESSION commences MONDAY, 22nd SEPTEMBER, 1919.

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UNIVERSITY OF MANCHESTER.

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A 234

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G. R.

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LOCOMOTIVES.

Locomotive, 4 ft. 8½ in. gauge, by Manning, Wardle & Co., Saddle Tank 125 lb. per sq. in., stroke 18 in. by 12 in. diam., approx. weight empty 16½ tons. Ref. M.K. 996. Lying at Royal Arsenal, Woolwich.

Oil Locomotives, by R. Hornsby & Sons, gauge 1 ft. 6 in., stroke 10 in. by 9 in. and 15 in. by 11 in., weight approx. 8 tons. Lying at Royal Ordnance Factory, Woolwich.

SACK CLEANING MACHINE.

Box 4 ft. by 3 ft. 3 in. by 5 ft. high, with Eight leather beaters on drums fitted on 1½ in diam. shaft. Secondary shaft having a rotary brush. Complete with movable grid for feeding sacks into machine, and six dust shoots. Lying at Main Supply Depôt, Glasgow. Ref. M.K. 9972.

10 TON LOCO. CRANE.

10 ton Loco. Crane, by Whittaker. Ref. M.K. 9972 Lying at A.C.S. Depôt, R.A.F., West Drayton.

ACETYLENE WELDING PLANT.

Six Acetylene Welding Plant, complete with generator and mountings, 15 in. diameter by 2 ft. 9 in. high, carbide container, Watchman type, 18 in. dia.

One Acetylene Welding Plant, Imperial type, with burners, &c. Lying at Portobello Aerodrome, Edinburgh.

ELECTRIC WINDING PLANT.

100 HP. Motor, 440 v. three-phase variable speed. Controller by Siemens. Oil immersed reverse current controller. Single 8 ft. drum with extended bed for motor, couplings, balance weights, 250 yards 1 in. wire rope, water lifting buckets, timber, &c. Lying at Government Cartridge Factory No. 1, Blackheath Depôt No. 92, Birmingham.

GRAVEL WASHING MACHINE.

Gravel Washing Machine with graduators to pea size, approx. output 75/100 yards per day. Belt-driven. Ref. M.K. 8058. Lying at Grain Island Firing Point, Isle of Grain, Yartlett Creek, Kent.

MORTAR PANS.

Three Mortar Pans. Ref. M.K. 8073.5.8. One Concrete Mixer and Engine combined. Ref. M.K. 8076. Lying at Henlow Repair Depôt, *via* Shefford, Beds. Ten Field Forges, 2 ft. dia. by 2 ft. 6 in. high, with bellows. Lying at Portobello Aerodrome, Edinburgh.

BEACON LIGHT PETROL AIR GAS GENERATOR by the British Motor Co., Ltd., suitable for 120 lights with generator; Gasometer, Feed Tank, Tower with pulleys, cable, etc. Ref. M.K. 7349. Lying at Strensall Camp, Yorkshire.

PLATE BENDING ROLLS for masts, capable of bending up to 12 ft. wide by ¾ in. dia. arranged for electric drive, driving by 40 HP. motor and 25 HP. motor for lifting top roll. Speed of motors 500 r.p.m., top roll so arranged that plate can be removed after being bent to a circle, no motors included. Overall dimensions 23 ft. 6 in. by 6 ft., without motors.

Lying at Works of Messrs. Berry & Co., Ltd., Croydon. Works: Leeds. Ref. M.K. 5826.

Tenders for above must be received not later than Ten a.m. on October 2nd. Tender Forms and Permits to view can be obtained on application to the CONTROLLER, D.B.1. (S), Charing Cross Embankment Buildings, London, W.C. 2.

NOTE.—For *Surplus*, the detailed list of surplus Government Property for sale, apply to the nearest bookstall or to a local newsagent (to whom a standing order should be given). Compiled by the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. Price 3d. A 8

HELL GATE BRIDGE, NEW YORK.

By FRANK W. SKINNER, M.Am.Soc.C.E.

(*Continued from page* 238.)

DETAILING TRUSS MEMBERS.

GENERAL and complete detail plans were prepared by the consulting engineer, and from them the contractor was required to prepare working drawings conforming to their specific features and dimensions but with the opportunity to make them consistent with his facilities for fabrication and erection and in accordance with the results of his experience in shop and field work. Some of these drawings have been reproduced on Plate XV; also on pages 296 and 297.

The particulars of the trusses for panel points 0 to 4 are given in Fig. 30, the details of the top and bottom laterals in Fig. 31, and the details of the floor system in Fig. 32, Plate XV. On page 296, Fig. 33, the details of the trusses for panel points 18 to 22 are given, and on page 297, Fig. 34 shows the details of the sway bracing and portals. The illustrations, Figs. 35 and 36, on page 312, give an excellent idea of the proportions and general lay-out of the main trusses.

All members were made of plates and angles riveted throughout and having riveted field connections, considerations that limited the cross sections to types composed of two main web plates with covers or diaphragms as required. All members have rectangular cross sections, and excepting the I-shape vertical suspenders are made of twin built-up channels or I-beams with their flanges connected by cover plates or latticing, and are stiffened by transverse plate diaphragms pierced with circular manholes at the centre and riveted to the webs through connection angles. In the diagonal web members the built channels have their flanges turned in and latticed.

On account of the size and thickness of the plates and angles very large rivets were used to reduce the size of the gusset connection plates to a minimum. The rivets in the bottom chords and in the field connections of all truss members are 1¼ in. in diameter with grips up to 9⅞ in., and all of the other rivets, except in secondary members, are 1 in. in diameter. Where the grip of the rivets exceeds four diameters the number of rivets required to transmit a certain stress is increased 1 per cent. for each additional ¼ in. of grip. Where spliced plates are not in direct contact with the parts they connect the number of rivets on each side of the joint is increased over the theoretical number required by 33 per cent. for each intervening plate. Rivets under stress passing through filler plates are increased in number in proportion to the thickness of the filler, being doubled for a thickness equal to the diameter of the rivets. Each individual plate or angle is spliced as directly as possible, avoiding the transfer of stresses through other pieces. In general both tension and compression joints are fully splice-riveted. The strength of every connection is sufficient to develop the full strength of the member even though the latter may be greater than the actual computed stress.

All panel point connections are made with two gusset plates 1 in. thick in the middle panel and 1⅛ in. thick in the other panels. The largest plates, 120 in. × 1⅛ in. × 17 ft. 6 in. were limited by the capacity of the rolling mills.

The web members are connected to the chords at panel points with their webs in the same plane as the large gusset plates and cut to clear them. Connections are made by double cover splice plates and by the projecting ends of the flange angles which form jaws engaging the gusset plates and have their outstanding legs connected by lug angles. The splice plates were shop riveted to the web members, the rivets nearest gusset plates being field driven to allow the pieces to spring and permit the entrance of the gusset plate during erection.

Where the flanges of channels and I-beams are connected by latticing special pains were taken to make the latter adequate, and it was proportioned everywhere to resist at any section at right angles to the axis of the member, a shearing force in pounds 300 times as great as the gross area of the member in inches. All latticing was made with angles at least ⅜-in. thick with two rivets at each end. The main truss members and laterals have double lattice angles inclined about 45 deg. to the axis of the member. One of each pair of lattice angles is spliced at the intersection by a square plate, and all lattice angles are placed inside the flange angles. Tie plates are placed as near as practicable to the ends of the members and always well within the edges of the gusset plates. All bottom chord cover plates are continuous across the panel points where they are notched out to clear the gusset plates. This insures an important increase in the stiffness and support of the webs beyond what would be provided if the tie plates were here omitted as is often done.

BOTTOM CHORDS.

The bottom chords have a maximum cross section of 1,392 sq. in. which with the exception of the 1,902 sq. in. bottom chords of the new Quebec Bridge, are the largest ever built. The chords have a uniform width of 6 ft. 6½ in. and have a closed double-box section consisting of two vertical webs, top and bottom cover plates, and a solid horizontal diaphragm through the neutral axis of the member. The effective gross sectional area varies from 929 sq. in. at the crown to 1,392 sq. in. at the skew back bearings. The over-all depth increases from 7 ft. at the crown to 10 ft. 10 in. at the skew backs where it was limited by transportation requirements that even with special low cars used would not permit any greater over-all depth. The variation in depth permitted a uniform thickness of the webs to be maintained thus facilitating the splicings.

The cross section of these chords is unusual in that it is entirely closed, a feature which on account of its large dimensions did not involve any material difficulty in riveting on the cover plates that necessitated the presence of a man inside the member to hold on the rivets. These chords are notable on account of the unusual thickness of 2 in. of the main web plates and of the centre diaphragms, which under numerous tests showed high elasticity and ultimate strength.

At panel points the web plates are cut to clear the gusset plates which really form short connecting sections of the web plates that project beyond the flanges of the chords to receive the web members. All parts of the chords that are not in the planes of the gusset plates extend to the butt joints and both web and flanges are spliced by double cover plates on both sides. Both sets of rivets are in double shear and the gusset plate itself acts as a splice.

As all the bottom chord sections make butt joints at panel points and as the planes of the joints are oblique to the axes of the chords and the angle varies at each point, the joints were of a very special and delicate nature and were particularly difficult to make on account of the extraordinary dimensions of the pieces. As it had previously been found difficult to make perfect joints in chords 4 ft. deep it was anticipated that it would be vastly more so with chords nearly 11 ft. deep, and it was proposed to insure positive bearing on the centre line of the chord by making the end of one section at the joint a straight plain surface at the required angle with the axis of the piece, and finishing the other end to a rounded surface tangent to the plain surface at the centre line.

During the investigation of this proposed joint the contractor finished two end pieces to the exact required planes and found that they made perfect contact, thus demonstrating the possibility of reliable joints. Eventually it was determined, however, to make one end as at first proposed with a single oblique surface at the required angle to the axis and to make the other end with the middle third of the radial surface planed to this angle and the two outer thirds tapered off to a clearance of ⅛ in. at the upper and lower edges of the chord. This concentrated the bearing pressure on the middle part of the joint and avoided dangerous edge pressures. When the chord members were first assembled the joint was made with full width bearing and afterwards one end of each chord section was bevelled so that at each outer third there was a wedge shape clearance ⅛ in. thick at the end. As the erection stresses were developed and the service bolts and drift pins were replaced by rivets these clearances were gradually diminished.

The outer thirds of the joints are spliced 100 per cent., the middle third being spliced only about 50 per cent. This gives a total efficiency of 70 per cent. or 80 per cent. of the effective area of the chord with a section modulus nearly equal to that of the main section. Considering both the splice and the bearing area of the middle third of the main section the total resisting area of the joint is from 110 per cent. to 120 per cent. of the normal chord section.

The bottom chord sections are unusual in that each web plate is made with an upper and a lower half having a full length longitudinal joint in the neutral axis of the member spliced inside and outside with two 40-in. by ⅜-in. cover plates with six rows of rivets. The maximum chord section with a gross area of 1,392 sq. in. is made up of four 62-in. by 2-in. web plates, twelve 8 in. by 8 in. by 1 in. flange angles, eight 40-in. by ⅜-in. splice plates, four 18-in. by 1⅝-in. flange reinforcement plates, eight 22-in. by ⅜-in. flange cover plates, two 50-in. by 1-in. top and bottom cover plates, and one 48-in. by 2-in. centre web plate.

The bottom chord splice at panel point L8 is made with two 94-in. by 1-in. plates 17 ft. 2½ in. long, two 93½-in. by ⅝-in. plates 12 ft. 11 in. long, two 18-in. by 1-in. plates 12 ft. 3½ in. long, two 23-in. by 1-in. plates 12 ft. 3 in. long, two 44-in. by ⅝-in. plates 7 ft. 9 in. long, and two 44-in. by ⅝-in. plates 7 ft. 5½ in. long.

TOP CHORD AND WEB MEMBERS.

The top chord and web members have a rectangular box section with two webs in vertical planes, and with cover plates connecting the flanges of the top chord and vertical end posts. The maximum top chord section of 385·6 sq. in. consists of two 44-in. by 1⅛-in. web plates, eight 8-in. by 8-in. by 1-in. flange angles, two 28-in. by 1-in. side plates, two 6½-in. by 1-in. by ½-in. flange plates, two 26-in. by 1-in. cover plates and one 44-in. by 1-in. cover plate. The chords are 6 ft. 8 in. wide over all and 3 ft. 9 in. deep back-to-back of flange angles. The splice at point U 23 is made with one 80-in. by 1 in. by 8 ft. 1 in., two 17½ in. by 1 in. by 11 ft. 11½ in., one 15½ in. by 1½ in. by 6 ft. 4 in., one 11½ in. by 1½ in. by 6 ft. 4 in. and three 6½-in. by ⅝-in. by 2 ft. 9 in. top plates, with two 37-in. by 1½-in. by 7 ft. 7½-in. side plates, and with two 8-in. by 8-in. by 1-in. by 10 ft. 9 in., two 8-in. by 8-in. by ½-in. by 14 ft. 7½ in. and two 6½-in. by ⅝-in. by 3 ft. 4-in. bottom pieces. The splices are made similarly to those in the bottom chord, except that both ends are planed to full bearing at the required angle. The depth of the end section of the top chord increases to 5½ ft. to give it a more massive appearance near the towers. Steps are provided in the interior of the chord for a passage way to the centre point where there is an opening to the exterior which is guarded by a pair of hand rails.

The end vertical members about 103 ft. long are made with two webs 5 ft. 1 in. deep and 4 ft. 8½ in. apart with the flanges at one side connected by a solid cover plate and on the other side latticed. Above floor level the webs are connected by a centre diaphragm plate. The gross area of 315 sq. in. in the lower part of the post is made up of two 60-in. by 1⅝-in. web plates, eight 8-in. by 8-in. by 1-in. flange angles, one 76-in. by ½-in. cover plate. The other verticals are of similar construction except that the web plates are only 4 ft. 7 in. wide and that the cover plates are omitted, both sides being latticed. The maximum gross area of 281·3 sq. in. consists of two 54-in. by 1⅝-in. web plates and eight 8-in. by 8-in. by ⅞-in. and ⅞-in. flange angles. The diagonal members are of similar construction with a maximum gross area of 201·8 sq. in. made up of two 48-in. by 1⅝-in. web plates and four 8-in. by 8-in. by ⅞-in. flange angles.

The vertical suspenders that in the centre of the span support the floor beams from the lower chords are of I-shape cross section 4 ft. deep with a gross area of 108 sq. in. and are made up of one 48-in. by 1-in. web plate and four 8-in. by 8-in. by 1-in. flange angles. The webs are perpendicular to the axis of the bridge, and in order to prevent the development of bending stress they are connected to the trusses and to the floor beams, with 16-in. top and bottom pins.

LATERAL AND SWAY BRACE SYSTEMS.

Each transverse panel between the two lines of top chords and between the two lines of bottom

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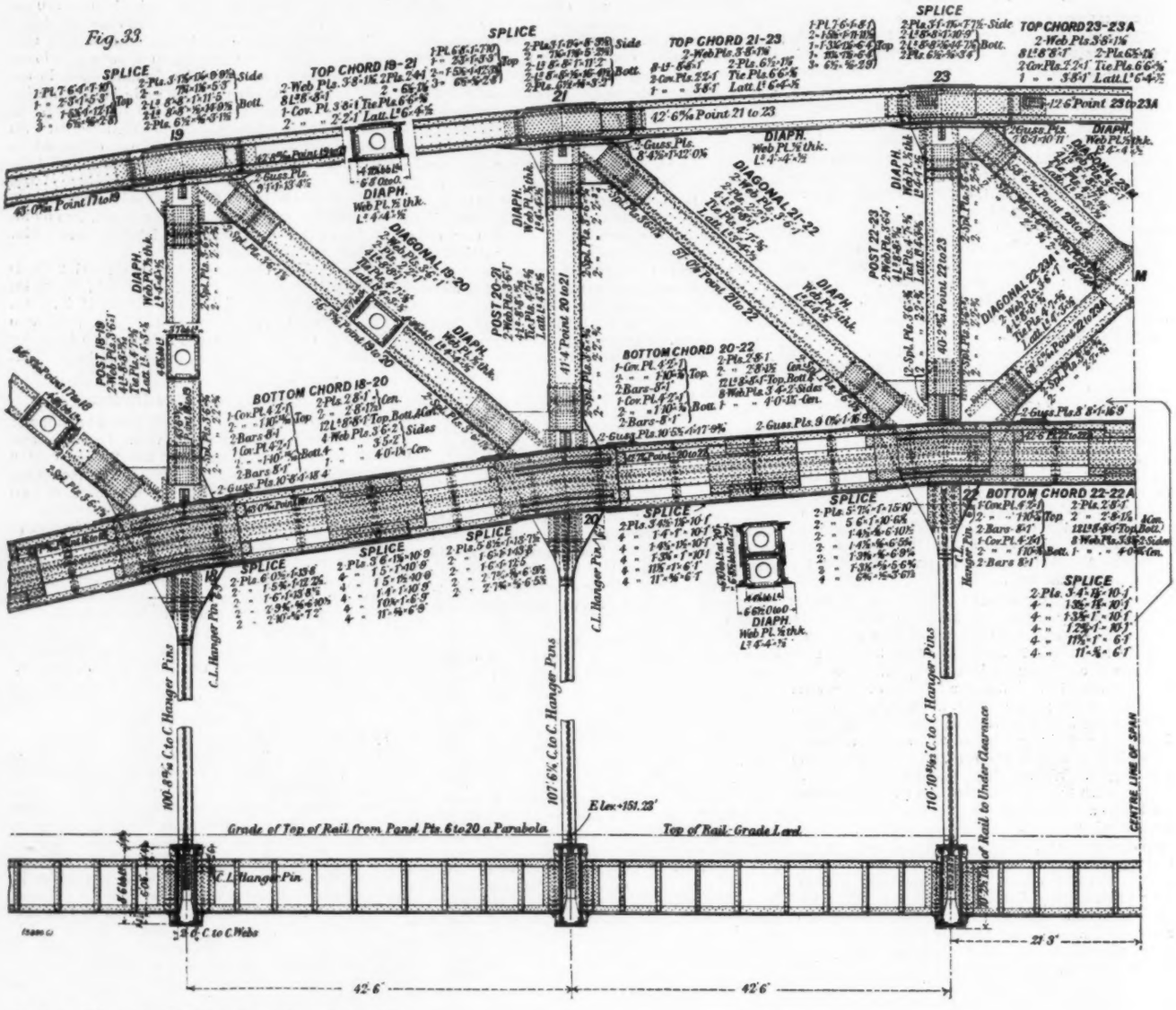
MR. GUSTAV LINDENTHALL, CHIEF ENGINEER.



chords is X-braced with riveted members designed to resist both tension and compression. These members have rectangular cross sections made with a pair of built channels 24 in. deep with their webs in horizontal planes and the flanges turned in and latticed. The ends are field riveted to jaw plates on the sides of the chords and at intersections one strut is cut to clear the other and is spliced across it by top and bottom flange cover plates. Lateral systems are proportioned not only to transmit wind stresses but to strengthen the compression members and prevent their buckling.

The stringers are 6 ft. deep with web connections to the floor beams and are connected in pairs with top and bottom lateral bracing and two sway frames in each panel.

The floor beams are heavy box girders with double webs 8½ ft. deep connected by top and bottom cover plates 42 in. wide, by vertical diaphragms in the planes of the stringers, and by horizontal diaphragms opposite the floor lateral connections. The full length suspended floor beams 93 ft. long weigh 86 tons each. The eight end floor beams about 60 ft. long terminate at the arch trusses and are extended beyond them with separate cantilever brackets.

FIG. 33. DETAILS OF TRUSSES; PANEL POINTS 18 TO 22.

The diagonal members of the floor lateral truss consist of built channels riveted across the bottom flanges of the track stringers. The channels are made of $\frac{11}{16}$-in. plates from 18 in. to 24 in. wide with two or four 6-in. by 4-in. by $\frac{1}{2}$-in. flange angles on the lower side. The diagonals take both tension and compression, and in their long unsupported length between the outside track stringers and the wind chords they are stiffened by latticed struts parallel with and 2 ft. above the diagonals connected to them by lattice angles.

At the expansion joints in the floor the two

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Fig. 34.

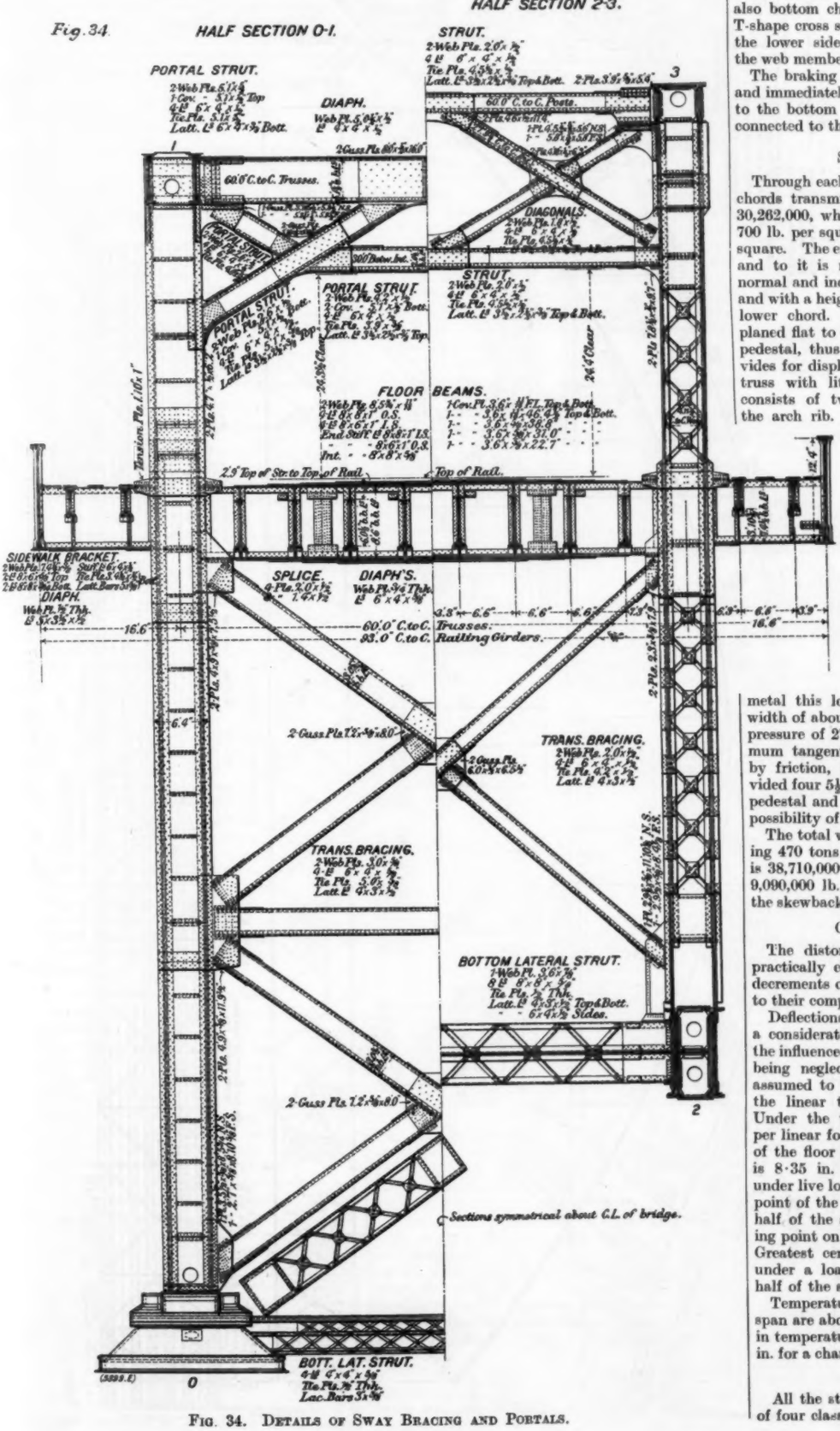


Fig. 34. Details of Sway Bracing and Portals.

diagonals on the sliding side are connected to a longitudinally movable horizontal gusset plate that transmits the lateral reaction to a bracket attached to the centre of the floor beams.

The chords of the floor-lateral truss, which are also bottom chords to the railing girders, have a T-shape cross section with the horizontal flange on the lower side and the vertical flange receiving the web members of the railing girders.

The braking girders have single webs 8 ft. wide and immediately below the floor laterals are framed to the bottom chords of the arch trusses and are connected to the stringers by vertical diaphragms.

Skewback Bearings.

Through each of the skewback bearings the lower chords transmit to the masonry a total force of 30,262,000, which is reduced to a unit pressure of 700 lb. per square inch on the bearing area 17½ ft. square. The end of the lower chord is planed square and to it is riveted a 30-ton steel casting with normal and inclined ribs 5 in., 6 in. and 8 in. thick and with a height of 5 ft. measured in the axis of the lower chord. The lower surface of this shoe is planed flat to engage the cylindrical surface of the pedestal, thus forming a rocker bearing that provides for displacement due to the distortion of the truss with little frictional resistance. The shoe consists of two 30-ton steel castings bolted to the arch rib. Each skewback pedestal is made up of 11 steel castings arranged in three crossed tiers with a total height of 15 ft. 5½ in. normal to the direction of pressure. The lower tier is seated on a 17 ft. 6 in. by 17 ft. 6 in. by 1-in. steel plate secured, without bedding, to the masonry by sixteen 2½-in. anchor bolts 10 ft. long. The cylindrical bearing surface of the pedestal has a radius of 1,150 in. designed for a maximum angular motion of 1 deg. 30 min. The bearing on the theoretical line of contact is 261,000 lb. per linear inch, but owing to the elasticity of the metal this load is practically distributed over a width of about 9½ in. on which there is a maximum pressure of 27,500 lb. per square inch. The maximum tangential force of 3,570,000 lb. is resisted by friction, in addition to which there are provided four 5½-in. dowels set in the lower part of the pedestal and engaging holes in the shoe to prevent possibility of its accidental displacement.

The total weight of steel in the arch span, including 470 tons of I-beams in the concrete floor slab, is 38,710,000 lb., of which the floor system weighs 9,090,000 lb., the arch trusses 21,640,000 lb., and the skewback bearings 1,990,000 lb.

Camber and Deflection.

The distortion due to dead load stresses was practically eliminated by providing increments or decrements of the length of members corresponding to their computed changes under stress.

Deflections under dead loads were calculated on a consideration of the gross area of all members, the influence of details and the rigidity of connection being neglected. The modulus of elasticity was assumed to be 30,000,000 lb. per square inch and the linear temperature expansion as 0·0000065. Under the total dead load averaging 51,000 lb. per linear foot of the bridge, the vertical deflection of the floor from its theoretical cambered position is 8·35 in. The maximum downward deflection under live load is 5·19 in. and occurs at the quarter point of the span under a load covering about one-half of the span. Simultaneously the corresponding point on the other end of the span rises 3·46 in. Greatest centre deflection is 3·82 in. and occurs under a load covering approximately the middle half of the span.

Temperature deflections at the centre of the span are about ·074 in. for each variation of 1 deg. in temperature making a total of plus or minus 5·3 in. for a change of 72 deg.

Material.

All the steel in the superstructure belongs to one of four classes, namely, hard steel, structural steel,

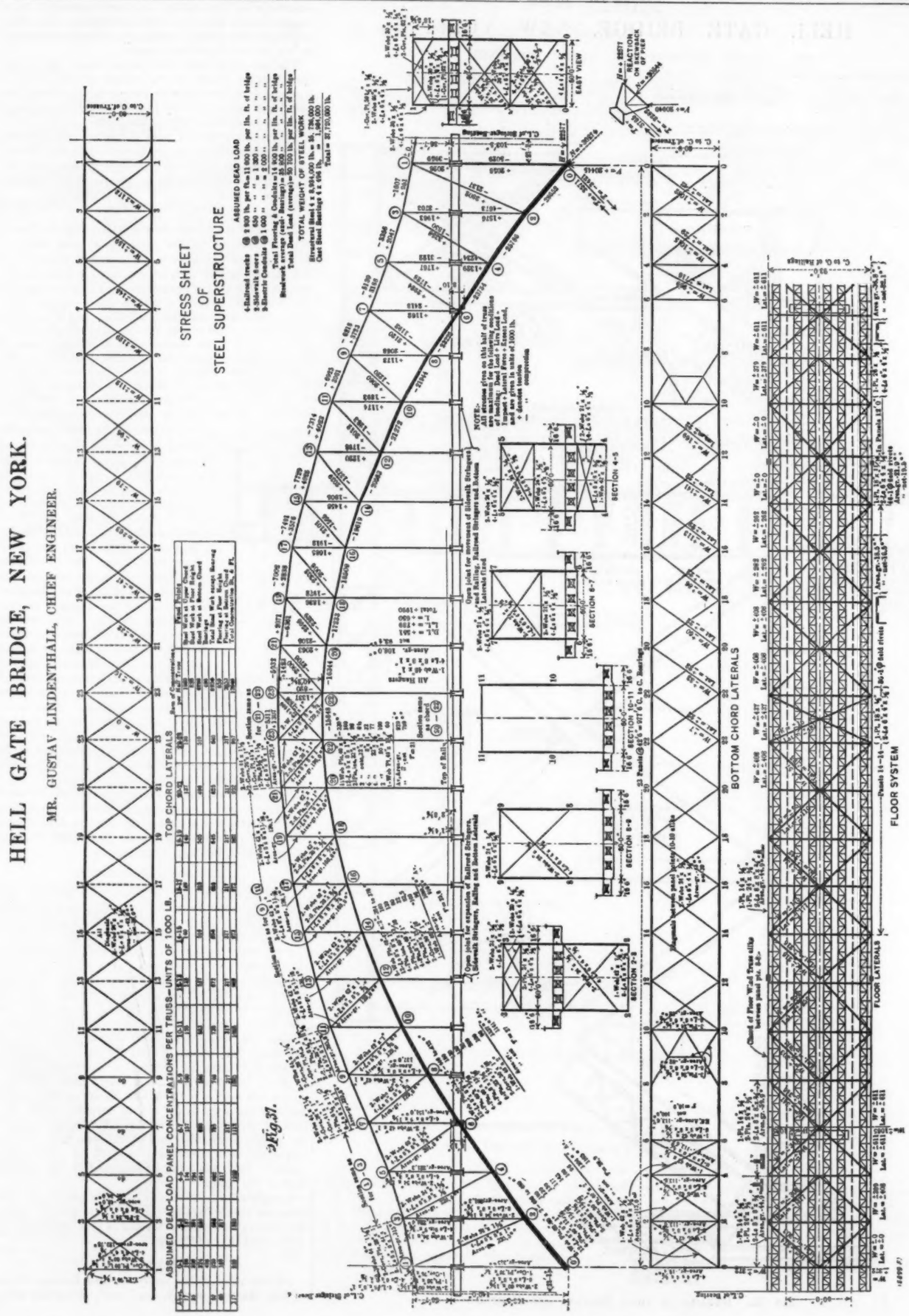


FIG. 37. INITIAL STRESS SHEET OF STEEL SUPERSTRUCTURE.

rivet steel, and steel castings. Metal was required to have the following physical and chemical properties.

TABLE I.

—	Hard Steel.	Structural Steel.	Rivet Steel.	Cast Steel.
Phosphorus, maximum—				
Basic	0·04	0·04	0·04	0·05
Acid	0·06	0·06	0·04	0·08
Sulphur, maximum ..	0·05	0·05	0·04	0·05
Ultimate tensile strength, in lbs. per square inch—				
Maximum	76,000	70,000	58,000	—
Desired	71,000	66,000	—	—
Minimum	66,000	62,000	50,000	65,000
Yield point, minimum ..	38,000	35,000	28,000	33,000
Elongation, minimum—				
In 2 in. for cast steel ..	*	22 per cent.	28 per cent.	20 per cent.
In 8 in. for other steel			Fine, silky.	Silky or fine granular
Character of fracture ..	Silky	Silky		
Cold bend without fracture	*	†	‡	§

* Minimum elongation for "hard steel": 1,400,000 divided by ultimate strength for thicknesses up to and including ¾ in.; 1 per cent. less for each additional ⅛ in. in thickness, with a limit of 16 per cent. for thicknesses up to and including 2 in. and 15 per cent. for thicknesses greater than 2 in.

Cold-bend test for "hard steel": 180 deg. around a pin of double the thickness of the test piece for material up to and including ¾ in., 180 deg. around a pin three times that thickness for material of greater thickness than ¾ in.

† 180 deg. around pin of thickness of test piece.

‡ 180 deg. flat.

§ 90 deg. around pin of thickness of test piece.

The chemical analysis was made from test ingots during the casting of the melt, and included the determination of carbon, manganese and silicon, in addition to phosphorus and sulphur. The carbon ranged between 0·27 per cent. and 0·34 per cent. in the hard steel and between 0·23 per cent. and 0·28 per cent. in the structural steel, and manganese from 0·52 per cent. to 0·64 per cent. and 0·36 per cent. to 0·61 per cent. respectively. Special stress was laid on sufficient discard being made from the ingot to insure sound material free from piping and excessive segregation.

Full-Sized Eye-Bar Tests.—About 1,900 tons of structural steel eye-bars, 16 in. wide and from 1⅞ in. thick to 2¾ in. thick, with forged heads 37½ in. in diameter, and 16-in. pin-holes were used in the Little Hell Gate Bridge. Twenty-one full-sized bars were tested, after annealing, and had to show the following results: ultimate strength: 56,000 lb. per square inch to 68,000 lb. per square inch; elastic limit; minimum, 33,000 lb. per square inch, and maximum, 38,000 lb. per square inch; minimum elongation in 10 ft.: 12 per cent.

The physical qualities were determined by about 7,000 tests, or an average of eight tests per 100 tons at the rate of from two to four tests per heat, according to the size of the latter. The hard steel showed an average elongation of about 25 per cent. and an average reduction of about 45 per cent. and met the bending tests without difficulty. It required extra hard tools for drilling and reaming in the fabricating shops.

LOADS AND STRESSES.

The assumed dead load was used for the production of the initial stress sheet, Fig. 37, page 298, and was then revised and the stress sheet corrected until the actual panel concentrations were very closely secured and the drawings were detailed, after which the weight was again calculated from the drawings and weights differing very slightly from the shipping weights were arrived at that varied from 45,000 lb. per linear foot to 62,000 lb. per linear foot with an average of 51,900 lb.

The live load stresses, Fig. 38, were computed from an alternative loading due to a Cooper's E-60 train on each of the four tracks, or an alternative three-axle load of 70,000 lb. on each axle.

The arch trusses were proportioned for uniform loads of 6,000 lb. per foot of track, or 24,000 lb. per foot of bridge, placed in the most unfavourable position either in a single loading or in two separate loadings. The statical stresses were increased by impact stresses determinated by the formula—

$$I = \frac{L^2}{D+L} \times \frac{1200 + \frac{a}{n}}{600 + 4a}$$

where D is stress from dead load in pounds, L is stress from live load in pounds, a is the length of the train behind the locomotive tender, in position of maximum stress, and n is the number of tracks loaded for maximum stress.

It was assumed that the greatest possible future increase of loading compatible with the present track and rolling-stock would give static stresses well within the limits of strength of all of the members except a few of the heaviest bottom chord pieces which might have required an increase of about 3½ per cent. As such extremely heavy loads would be moved slowly it was considered justifiable to neglect the effects of impacts for them, the bridge therefore being considered safe for any possible loadings that may be applied to it.

The lateral force due to the swaying motion of fast-moving trains on tangents, or the centrifugal force on curves up to 2 deg., has been assumed at 600 lb. per linear foot of single track and at 300 lb. for each additional degree of curvature up to 6 deg., and an increase of 50 per cent. was made for each additional track, thus giving for a four track bridge on a tangent a total lateral force of 1,500 lb. per foot. As this force may act at any time it is considered in combination with the regular wind stresses.

Wind pressure was assumed as a moving load of 500 lb. per linear foot of bridge at track level, plus a static load of 30 lb. per square foot on all such vertical surfaces of the unloaded bridge as are exposed at an angle of between 20 deg. above and 20 deg. below the horizontal or at an angle of 45 deg. from the axis of the bridge. This resulted in an average wind pressure of 600 lb. per linear foot of horizontal projection of top chord, 1,000 lb. per linear foot of horizontal projection of bottom chord, and 1,500 lb. per linear foot of floor inclusive of the 500 lb. moving wind pressure, or a total of 3,100 lb. per linear foot of bridge.

The longitudinal force at rail level from traction and braking was assumed either as 16,000 lb. for

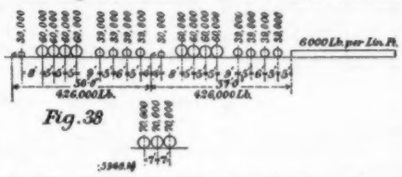


Fig. 38

each of the eight driving axles of the two locomotives, or as 1,000 lb. per linear foot of train, according to which gave the greatest result.

Stresses from temperature were determined for a variation of 72 deg. in either direction from the normal of 60 deg. F. They are maximum at the centre of the top chord where they attain a value of 4,000 lb. per square inch equal to about 40 per cent. of the live load stresses.

1. For members which carry dead and live load, the "total stress" was obtained by adding with stresses from dead load (D), live load (L), impact (I), lateral force (Lat.), and the so-called "excess stress" (Exc.). This excess is the sum of the stresses from wind pressure (W), braking force (B), and temperature (T), less 20 per cent. of the sum (D + L + I + Lat.). This is equivalent to allowing up to 25 per cent. higher unit stresses for the sum (D + L + I + Lat. W + B + T) than for the previously mentioned "total stress," the percentage decreasing with increasing value of (W + B + T).

2. For members which carry no dead and live load, the "total stress" was made equal to (W + B + T + Lat.). The "total stress," divided by the permissible unit stress, gave the minimum required area.

UNIT STRESSES.

An unusual distinction was here made by permitting greater compression stresses in members having solid diaphragms or cover plates than in other members having flanges connected only by latticing. For members with a closed section or with a section having two diaphragms or with one diaphragm and two planes of latticing the unit stresses vary from 24,000 to 15,000 for values of $\frac{l}{r}$ from 20 to 120. For a half open section with one cover and one latticing or with one diaphragm without latticing, the corresponding unit stresses varied from 23,000 to 14,000. For an open section with two or more planes of latticing the correspond-

TABLE II.—*Permissible Unit Stresses Assumed.*

—	For Trusses and Bracing of Hell Gate Bridge (Hard Steel). (In lbs. per square inch).	For Approach Spans and Floor System and Suspenders of Hell Gate Bridge (Structural Steel). In lbs. per square inch.
Axial tension, net section ..	24,000	20,000
Bending on extreme fibre of beams, girders, and steel castings, net section	—	20,000
Axial compression, net section—		
(a) Closed section, or section with two diaphragms, or one diaphragm and two planes of latticing .. .. .. $\frac{l}{r}$ = 20	24,000	20,000
40	23,000	19,000
60	22,000	17,000
80	20,000	15,000
100	18,000	14,000
120	15,000	12,000
(b) Half-open section, with one cover and one latticing, or with one diaphragm without latticing .. $\frac{l}{r}$ = 20	23,000	20,000
40	22,000	18,000
60	22,000	16,000
80	18,000	14,000
100	16,000	13,000
120	14,000	11,000
(c) Open section, with two or more planes of latticing .. $\frac{l}{r}$ = 20	22,000	19,000
40	20,000	17,000
60	18,000	15,000
80	16,000	13,000
100	14,000	12,000
120	12,000	10,000
Shearing stress per square in.—		
On plate girders, net section ..	—	15,000
Shop rivets and pins	15,000	—
Field rivets and turned bolts ..	12,000	—
Bearing stress per square in.—		
Pins	24,000	20,000
Shop rivets	30,000	—
Field rivets and turned bolts ..	24,000	—
Pressure on—		
Expansion rollers per linear inch	Diameter of rollers, in inches ×1,000	
Granite masonry (per sq. in.) ..	800	800
Concrete masonry	600	800

ing stresses varied from 20,000 to 12,000. An axial strain of 24,000 lb. was allowed on the net section. Shearing stress on shop rivets and pins 15,000; field rivets and turned bolts 12,000; bearing stress on pins 24,000; shop rivets 30,000; field rivets and turned bolts 24,000; iron granite masonry 800 and on concrete masonry 600 lb. per square inch.

The maximum calculated secondary stresses that occur simultaneously with the maximum primary stresses in pounds per square inch are for the bottom chord; dead load 1,300 live load 1,300, combined dead and live 2,100, top chord; dead load 2,100, live load 3,100 combined 5,200; diagonals dead 5,000, live 2,800, combined, 6,300; verticals dead, 2,200, live 4,400, combined 4,800. These, being extreme fibre stresses, are assumed to be covered by the margin of safety in the primary or axial stresses. No attempt was made in the fabrication and erection of the trusses to eliminate or even reduce the secondary stresses.

The greatest erection stresses in the arch trusses were: + 18,600 and — 16,660 lb. without wind, and + 20,400 lb. and — 19,700 lb. with an assumed wind pressure of 30 lb. per square foot of exposed surface. Only in the end panel of the top chord was the erection stress greater than the total stress in the permanent bridge, but these members required a certain minimum section which was sufficient for the erection stress. No extra metal was required, therefore, in the arch trusses for erection purposes. The maximum values allowed for the erection stresses without wind in the temporary structural steel backstays were 20,000 lb. per square inch tension and 25,000 lb. per square inch with a wind pressure of 30 lb. per square foot of exposed surface.

(To be continued.)

WATER-POWER IN THE DUTCH INDIES.—The water-power possibilities of the Dutch Indies have recently been surveyed and the available water power so far discovered amounts to 1,000,000 h.p. Conditions would allow of power stations of 100,000 h.p. being established in certain districts. It is proposed to establish factories for the production of nitrates from the air in Central Celebes and Sumatra, but the cost of harnessing the water power has apparently not yet been fully investigated.

THE EFFECT OF CARBON DIOXIDE WHEN PRESENT IN INFLAMMABLE GASEOUS MIXTURES ON EXPLOSION PHENOMENA.

By Major W. T. DAVID, M.A., Assoc.M.Inst.C.E.

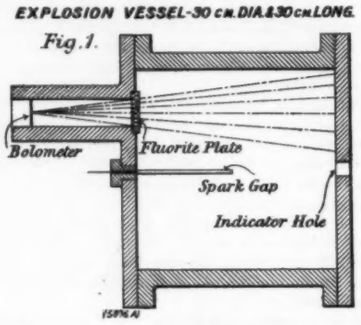
Introduction.—1. Shortly after completing a research on the emission of radiation from exploded mixtures of Cambridge coal-gas and air of various strengths and densities the author made a number of experiments on the effect of replacing the nitrogen of the air in such mixtures by CO_2. The results of these experiments which have not been previously published are of considerable interest, as indicating the kind of influence which products of combustion when mixed with the working fluid in the cylinder of an internal-combustion engine have upon working pressures and heat loss to the walls of the cylinder.

2. The experiments were originally made to discover whether the presence of a gas like CO_2 (which absorbs radiation of the wave-lengths emitted by an exploded mixture of coal-gas and air) had any influence in reducing the large heat loss due to radiation from the mass of the hot gaseous mixture.

Curve B: 15 per cent. coal-gas, 26·4 per cent. oxygen and 58·6 per cent. CO_2.

Curves C and D*: 15 per cent. coal-gas, 19·7 per cent. oxygen and 65·3 per cent. CO_2.

* Curves C and D it will be noted relate to mixtures of the same composition, but for some reason or other the rate of explosion was slower in the one than in the other. In some ways this appeared to be a critical mixture (see description of experiment in §10) and possibly a slight difference in mixing was sufficient to account for the different rates of development of pressure.



For purposes of comparison the pressure records of a 10 per cent. and a 15 per cent. mixture of coal-gas and air are included (dotted curves E and F).

It will be convenient to refer to the mixtures containing coal-gas, oxygen and CO_2, as the CO_2 mixtures, and the coal-gas and air mixtures as the nitrogen mixtures.

From curves B, C and D, which give the pressure records of 15 per cent. mixtures of coal-gas with varying quantities of CO_2, and curve E, which is the pressure record for a 15 per cent. mixture of coal-gas and air, it will be seen immediately that the presence of CO_2 reduces greatly the maximum pressures developed and slows down the speed of combustion; and, further, that the greater the proportion of CO_2 the lower the pressures and the slower the burning. In the 15 per cent. coal-gas and air explosion a maximum pressure of 105 lb. per square inch (gauge) was reached in $\frac{1}{10}$ second, whereas in the mixture containing 15 per cent. coal-gas and 58·6 per cent. CO_2 a maximum pressure of only about 68 lb. per square inch was developed in $\frac{3}{20}$ second (*i.e.*, three times as long) and in the

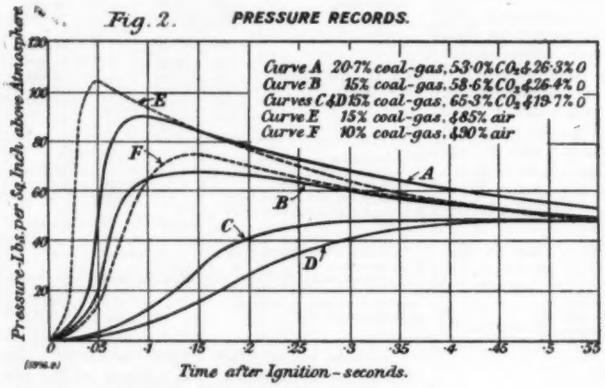


Fig. 2. PRESSURE RECORDS.
Curve A 20·7% coal-gas, 53·0% CO2 & 26·3% O
Curve B 15% coal-gas, 58·6% CO2 & 26·4% O
Curves C & D 15% coal-gas, 65·3% CO2 & 19·7% O
Curve E 15% coal-gas, 85% air
Curve F 10% coal-gas, 90% air
Pressure-Lbs. per Sq. Inch above Atmosphere
Time after Ignition-seconds.

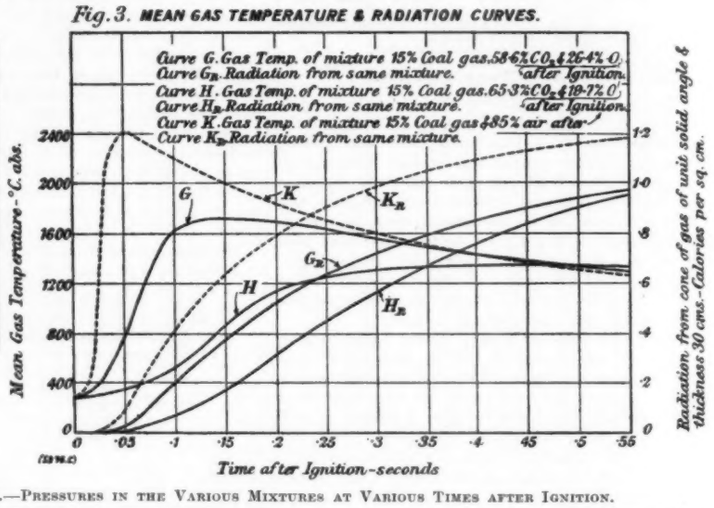


Fig. 3. MEAN GAS TEMPERATURE & RADIATION CURVES.
Curve G. Gas Temp. of mixture 15% Coal gas, 58·6% CO2 & 26·4% O
Curve G2. Radiation from same mixture.
Curve H. Gas Temp. of mixture 15% Coal gas, 65·3% CO2 & 19·7% O
Curve H2. Radiation from same mixture.
Curve K. Gas Temp. of mixture 15% Coal gas & 85% air after Ignition.
Curve K2. Radiation from same mixture.
after Ignition.
Mean Gas Temperature - °C. abs.
Radiation from cone of gas of unit solid angle & thickness 30 cms.-Calories per sq. cm.
Time after Ignition-seconds

As will be seen presently the radiation loss was considerably reduced, but on analysis the reduction was found to be due entirely to the lower temperatures developed in these mixtures. Indeed, had the temperatures not been reduced owing to the presence of CO_2 the radiation emitted would have been much greater than that from the coal-gas and air mixtures.

3. A full description of the apparatus used will be found in a paper recording the results of the coal-gas and air experiments published in the Philosophical Transactions of the Royal Society (Series A, vol. ccxi, pages 375 to 410). For the purpose of this paper it is sufficient to draw attention to the general arrangements of the explosion vessel, which are shown diagrammatically in Fig. 1. The vessel consisted of a cast-iron cylinder, 30 cm. in diameter and 30 cm. in length; its capacity was 0·788 cub. ft. In the experiments about to be described the interior surface was painted over with a thin layer of dull black paint. The mixtures were ignited by means of an electric spark in the centre of the vessel and the pressures were recorded by means of a Hopkinson optical indicator which reflected a spot of light on to a revolving photographic film. The radiation from the exploded mixtures was measured by means of a platinum bolometer protected from the gaseous mixture by means of a plate of fluorite, which is highly transparent to radiation of the wave-lengths emitted by the hot gaseous mixtures. The heat received by the bolometer (which is proportional to the rise of its electrical resistance) was measured by means of a reflecting galvanometer, which reflected a spot of light on to the same rotating film which was used for recording pressure. The pressures and radiation emitted could therefore be recorded simultaneously and generally covered a period of from 2 seconds to 3 seconds after ignition.

4. *Pressures Developed and Rate of Explosion.*—In Fig. 2 are given pressure records to a time base for explosions of the following mixtures:—

Curve A: 20·7 per cent. coal-gas, 26·3 per cent. oxygen and 53 per cent. CO_2.

TABLE I.—PRESSURES IN THE VARIOUS MIXTURES AT VARIOUS TIMES AFTER IGNITION.

Time after Ignition.	Pressure in Pounds per Square Inch (Gauge).						
	Mixture: Per Cent. 20·7 Coal-Gas, 26·3 Oxygen, 53·0 CO_2.	Mixture: Per Cent. 15·0 Coal-Gas, 26·4 Oxygen, 58·6 CO_2.	Mixture: Per Cent. 15·0 Coal-Gas, 19·7 Oxygen, 65·3 CO_2.	Mixture: Per Cent. 15·0 Coal-Gas, 19·7 Oxygen, 65·3 CO_2.	Mixture: Per Cent. 15·0 Coal-Gas, 85·0 Air.	Mixture: Per Cent. 12·5 Coal-Gas, 87·5 Air.	Mixture: Per Cent. 10·0 Coal-Gas, 90·0 Air.
0·05	—	—	—	—	105 (max. pres.)	—	—
0·07	—	—	—	—	—	91 (max. pres.)	—
0·088	91 (max. pres.)	—	—	—	—	—	—
0·1	90·5	—	—	—	95	86	—
0·14	—	—	—	—	—	—	75 (max. pres.)
0·15	85	68 (max. pres.)	—	—	85	78	74
0·2	79	67	(41)	(31)	77	72	70
0·25	74	64	(46·5)	(35)	70	67	65
0·3	69	60	(47·5)	(41)	64	62	61
0·35	65	58	(48·5)	(44)	60	59	58
0·4	62	55	49 (max. pres.)	(46·5)	55	55	55
0·45	58	53	49	(48·5)	53	53	53
0·5	56	51	49*	(49)†	49	49	49

* Maximum pressure remains at 49 lb. per square inch until about 0·8 second after ignition.
† Maximum pressure at about 49·5 lb. per square inch is developed at about 0·65 second after ignition.

TABLE II.—15 PER CENT MIXTURES. GAS TEMPERATURES AND RADIATION FROM CONE OF GAS OF UNIT SOLID ANGLE AT VARIOUS TIMES AFTER IGNITION.

Time after Ignition.	Mixture: 15 per Cent. Coal-Gas, 58·6 per Cent. CO_2 and 26·4 per Cent. Oxygen.		Mixture: 15 per Cent. Coal-Gas, 65·3 per Cent. CO_2 and 19·7 per Cent. Oxygen.		Mixture: 15 per Cent. Coal-Gas, and 85 per Cent. Air.	
	Mean Gas Temperature, Deg. C. Abs.	Radiation in Cals. per Sq. Cm. of Bolometer Surface.	Mean Gas Temperature, Deg. C. Abs.	Radiation in Cals. per Sq. Cm. of Bolometer Surface.	Mean Gas Temperature, Deg. C. Abs.	Radiation in Cals. per Sq. Cm. of Bolometer Surface.
0·05	760	0·03	380	—	2,400	0·11
0·1	1,610	0·2	540	0·07	2,200	0·43
0·15	1,720	0·38	880	0·18	2,000	0·64
0·2	1,690	0·42	1,130	0·3	1,830	0·80
0·25	1,630	0·53	1,240	0·44	1,650	0·91
0·3	1,560	0·63	1,300	0·56	1,590	0·98
0·35	1,500	0·69	1,330	0·66	1,500	1·05
0·4	1,440	0·75	1,340	0·74	1,420	1·09
0·45	1,380	0·8	1,340	0·82	1,380	1·13
0·5	1,350	0·84	1,340	0·88	1,320	1·15
0·55	1,320	0·87	1,340	0·94	1,270	1·17

mixture containing 15 per cent. coal-gas and 65·3 per cent. CO_2 the maximum pressure (49 lb. per square inch) developed is only about half that developed in the 15 per cent. coal-gas and air mixture, and the development of this pressure took from $\frac{6}{10}$ second to $\frac{8}{10}$ second.

The mixture containing 20·7 per cent. coal-gas and 53 per cent. CO_2 developed a maximum pressure of about 91 lb. per square inch in about 0·085 second. This is about the maximum pressure developed in a 12·5 per cent. mixture of coal-gas and air, and it is developed in about the same time. (A 12·5 per cent. mixture of coal-gas and air would give a pressure record lying about midway between curves E and F.)

It will be noticed that in all the CO_2 mixtures the cooling proceeds more slowly than in the nitrogen mixtures.

Table I showing the pressures at various times after ignition has been compiled from the curves shown in Fig. 2.

5. The lower maximum pressures produced in the CO_2 mixtures are due in a large measure to the greater volumetric or specific heat of CO_2, as compared with that of nitrogen at high temperatures. There is considerable evidence, too, that whatever may be the truth as regards the "after-burning" or "continued combustion" theory in the nitrogen mixtures a considerable volume of chemical activity is proceeding at the moment of maximum pressure in the CO_2 mixtures, and indeed for some time during cooling.* This would indicate that a considerable fraction of the chemical energy of the inflammable gas has not been converted at maximum pressure into thermal energy, and is therefore latent in the mixture so far as pressure energy is concerned.

6. *Radiation Measurements.*—In Figs. 3, 4 and 5 are given curves of mean gas temperature, and also of the radiation emitted from a cone of gaseous mixture of unit solid angle and of length or thickness equal to the length of the explosion vessel, viz., 30 cm. The mean gas temperature curves have been calculated from the pressure records by means of the equation $\theta = \frac{p.v.}{R}$ after allowing for a small contraction of volume—of the order of 3 per cent.—which occurs during the combustion of coal-gas. All radiation measurements in these experiments were made when the bolometer was 5 in. away from the plate of fluorite and the cone of gaseous mixture (see Fig. 1) thus "seen" by a point on the bolometer surface had a solid angle of 0·062. The radiation curves in the figures were calculated from the curves of heat received by the bolometer per square centimetre of its surface (after making an allowance of 5 per cent. for absorption of the fluorite plate and 5 per cent. for reflection from the blackened surface of the platinum bolometer) and dividing by 0·062 so as to give the radiation from a cone of the gaseous mixture of unit solid angle.

7. In Fig. 3 are given the radiation curves from 15 per cent. mixtures of coal-gas with varying proportions of CO_2. The dotted curves in the figure (K and K) refer to a 15 per cent. mixture of coal-gas and air and are here included for purposes of comparison.

It will be seen at once that the radiation emitted by the CO_2 mixtures is considerably less than that from the nitrogen mixture—particularly in the early stages. At 0·25 second after ignition the radiation emitted by the nitrogen mixture is from 50 per cent. to 100 per cent. greater than that from the CO_2 mixtures; at 0·55 second after ignition it is from 20 per cent. to 25 per cent. greater; and at 1 second after ignition* (after which the radiation emitted is negligible) it is from 5 per cent. to 10 per cent. greater.

Table II has been prepared from the curves in this figure. It shows both the mean gas temperatures and the emission from unit solid angle at various times after ignition.

The radiation is emitted almost entirely by CO_2 and steam, and Table III has been prepared showing the proportions of these gases present in the gaseous mixtures after explosion. In the CO_2 and nitrogen mixtures containing initially 15 per cent. of coal-gas, the proportion of steam present after combustion is the same (viz., 20 per cent.), but in the CO_2 mixtures there is from eight to nine times as much CO_2 as there is in the nitrogen mixture. But on the other hand the temperature developed in the CO_2 mixtures are much lower than those in the nitrogen mixture and to this must be ascribed the smaller amount of radiation emitted.

8. In Fig. 4 are given mean gas temperature and radiation curves for a mixture containing 20·7 per cent. of coal-gas and 53 per cent. of CO_2 (X curves), and also for a mixture of 15 per cent. coal-gas and 85 per cent. air (Y curves). The radiation from the former mixture is much greater (about 30 per cent. greater at 0·5 second after ignition) than that from the latter mixture—except in the very early stages, when the radiation from the latter is a little greater than that from the former. The rate of emission (see intrinsic radiance curves—shown dotted, which are the differentials of the radiation curves) is also much greater from the former mixture than from the latter throughout cooling—except in the very early stages (up to about 0·07 second after ignition).

9. Intrinsic radiance values are plotted against mean gas temperatures in Fig. 5 for the various mixtures. Curves P and Q relate to CO_2 mixture and curves R and S to nitrogen mixtures. The P and Q curves show clearly that the CO_2 mixtures radiate much more strongly than the nitrogen mixtures in the neighbourhood of maximum temperatures and further that the CO_2 mixtures radiate most strongly during the explosion period—*i.e.*, before the gas temperature attains its maximum value.† Later on, when equilibrium conditions may be assumed to have more or less set in the rate of emission from the CO_2 mixture approximates to that from the nitrogen mixtures at the same temperatures.

A gas which, like CO_2, or steam, is capable of emitting radiation radiates much more strongly when undergoing chemical combination‡ and it is highly probable that the large emission from the CO_2 mixtures when they are in the neighbourhood of maximum temperature is due in a large measure to chemical activity proceeding during this time in considerable volume. The radiation measurements indicate that chemical activity may be going on until the mean gas temperature has fallen to about

TABLE III.—COMPOSITION OF THE CO_2 AND NITROGEN MIXTURES AFTER EXPLOSION.

Mixture before Explosion.	Mixture after Explosion.
20·7 per cent. coal-gas, 53 per cent. CO_2 and 26·3 per cent. oxygen	64·7 per cent. CO_2, 28 per cent. steam, and remainder mainly oxygen.
15 per cent. coal-gas, 58·6 per cent. CO_2 and 26·4 per cent. oxygen	67·1 per cent. CO_2, 20 per cent. steam, and remainder mainly oxygen.
15 per cent. coal-gas, 65·3 per cent. CO_2 and 19·7 per cent. oxygen	73·8 per cent. CO_2, 20 per cent. steam, and remainder mainly oxygen.
15 per cent. coal-gas and 85 per cent. air	8·5 per cent. CO_2, 20 per cent. steam, and remainder mainly nitrogen plus a little excess oxygen.
10 per cent. coal-gas and 90 per cent. air	5·7 per cent. CO_2, 13·3 per cent. steam, and remainder mainly nitrogen plus excess oxygen.

Fig. 4. MEAN GAS TEMPERATURE & RADIATION CURVES.

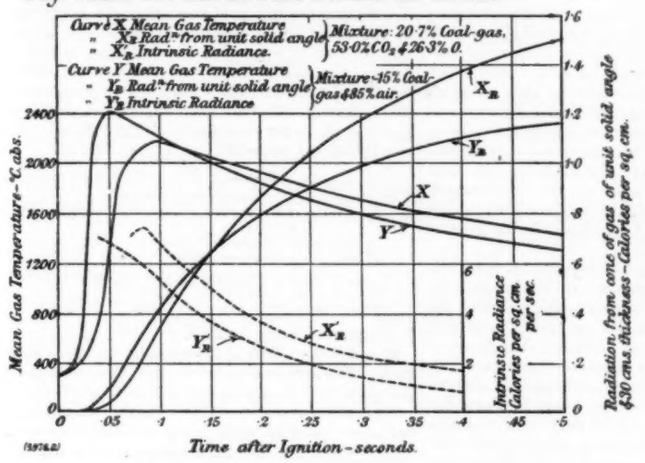

Curve X Mean Gas Temperature
" X_R Rad^n from unit solid angle
" X_I Intrinsic Radiance.
Mixture: 20·7% Coal-gas, 53·0% CO_2 26·3% O.
Curve Y Mean Gas Temperature
" Y_R Rad^n from unit solid angle
" Y_I Intrinsic Radiance
Mixture 15% Coal-gas 85% air.
Mean Gas Temperature - °C. abs.
Intrinsic Radiance Calories per sq. cm. per sec.
Radiation from cone of gas of unit solid angle & 30 cms. thickness - calories per sq. cm.
Time after Ignition - seconds.

Fig. 6. MEAN GAS TEMPERATURE & RADIATION CURVES.

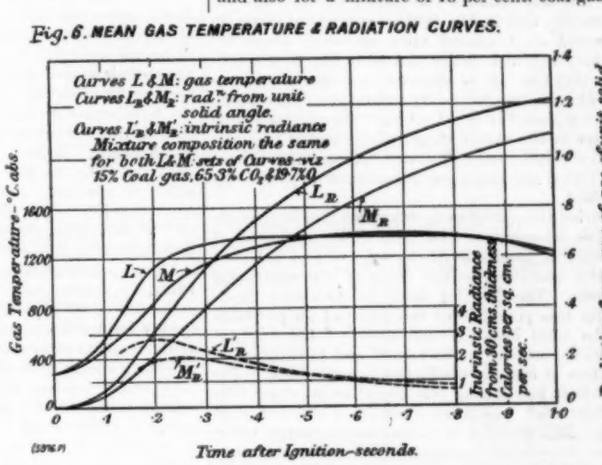
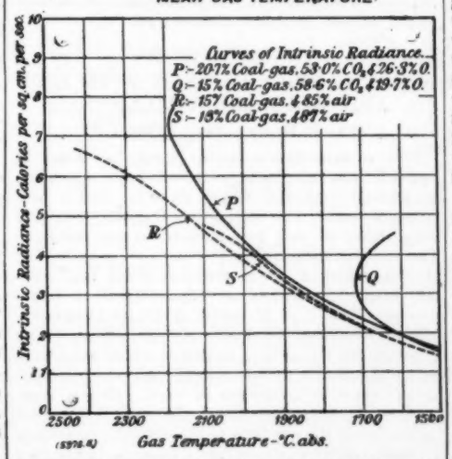

Curves L & M: gas temperature
Curves L_R & M_R: rad^n from unit solid angle.
Curves L_I & M_I: intrinsic radiance
Mixture composition the same for both L & M sets of Curves - viz 15% Coal gas, 65·3% CO_2, 19·7% O.
Gas Temperature - °C. abs.
Intrinsic Radiance from 30 cms. thickness Calories per sq. cm. per sec.
Radiation from cone of gas of unit solid angle & thickness 30 cms.
Time after Ignition - seconds.

Fig. 5. INTRINSIC RADIANCE PLOTTED AGAINST MEAN GAS TEMPERATURE.


Curves of Intrinsic Radiance.
P - 20·7% Coal-gas, 53·0% CO_2 26·3% O.
Q - 15% Coal-gas, 58·6% CO_2 19·7% O.
R - 15% Coal-gas, 85% air
S - 15% Coal-gas, 90% air
Intrinsic Radiance - Calories per sq. cm. per sec.
Gas Temperature - °C. abs.

* This evidence is examined in §§9 and 10.

* The radiation 1 second after ignition is not shown in Fig. 3.

† A similar result was found in the case of the nitrogen mixtures (see Phil. Trans. Roy. Soc., A, vol. ccxi, page 351).

‡ See Phil. Trans. Roy. Soc., A, vol. ccxi, page 410.

1,900 deg. C. (absolute)—*i.e.*, one-fifth second after ignition—in the case of CO_2 mixture containing 20·7 per cent. coal gas; and in the case of the mixture containing 15 per cent. of coal-gas and 58·6 per cent. CO_2 it appeared to be going on until the gas temperature fell to about 1,650 deg. C, (absolute)—*i.e.*, about one-quarter second after ignition. After these temperatures the CO_2 mixtures appear to have attained more or less to equilibrium conditions, and the radiation then emitted is only a very little greater than that given out by the nitrogen mixtures after they have fallen to the same temperatures—although they contain very much more radiating gas than the nitrogen mixtures. This indicates that the CO_2 mixtures at these temperatures are much less transparent than the nitrogen mixtures to radiation of the same kind as they emit.

10. It will be remembered that the mixtures containing 15 per cent. of coal-gas and 65·3 per cent. CO_2 gave pressure curves in which the maximum pressure remained practically constant over a long period of time (nearly 0·5 second). The radiation and intrinsic radiance curves for this mixture are interesting and in Fig. 6 these curves are given for a period of 1 second after ignition. From the intrinsic radiance curves (dotted in Fig. 6) it will be seen that the rate of emission is a maximum some considerable time before the attainment of maximum pressure and, further, that the rate of emission is greater in the earlier stages of the period of maximum pressure than in the later, although throughout this period the mean gas temperature is practically constant.

During the period of constant maximum pressure or gas temperature the rate of development of pressure or translational energy was just balanced by the heat loss to the walls of the containing cylinder. The loss of heat by radiation alone during this period is of the order of 10 per cent. of the total heat of combustion of the coal-gas originally present in the vessel* and in addition to this loss of heat by conduction is proceeding. The total heat loss during this period is therefore very considerable† and there must be a conversion of energy into pressure or translational energy going on in considerable volume. Indications are that this is mainly a conversion from chemical energy.

In this connection an experiment which the author made‡ with this mixture in a glass tube is of considerable interest. The glass tube was about 4 in. in diameter and about 5 ft. long, and the mixture after being introduced into this tube was ignited by a spark at one end. Ignition took place immediately, and a bluish flame rushed rapidly along the tube until it came to within about 6 in. or 9 in. of the other end, when it appeared to die out more or less. The interpretation of this would appear to be that chemical activity proceeded at first with considerable vigour, but that in the final stages combustion proceeded so slowly that it was unaccompanied by the emission of luminous radiation in sufficient quantity to affect the eye. It would seem probable that the slow combustion stage in the glass tube coincided more or less with the period of constant maximum pressure in the cast-iron explosion vessel.

11. *Summary and Conclusions.*—These experiments show clearly that inflammable mixtures of coal-gas and oxygen produce far lower pressures on explosion when they are mixed with CO_2 than when they are mixed with nitrogen as a diluting gas. They also show that CO_2 has a marked influence in slowing down the rate of combustion. It is highly probable that the CO_2 slows down the rate of burning to such an extent that a considerable fraction is still unburnt at the moment of maximum pressure.§ This, in conjunction with the high volumetric heat of CO_2 at high temperatures, appears to be mainly responsible for the lower pressures produced in the CO_2 mixtures.

12. These experiments seem to indicate the importance of reducing the proportion of products of combustion in the charge of an internal-combustion engine to the minimum possible. This is all the more important in the case of an engine which is worked on mixtures of moderate strength. An engine worked on mixtures of moderate strength gives a higher thermal efficiency than when worked on strong mixtures; but with such mixtures there is the disadvantage of comparatively slow burning, and the effect of the presence of products of combustion would be to slow down the rate of burning still more as well as tend to reduce the pressures developed.* It should be borne in mind, however, that these experiments were made with mixtures containing CO_2 in far larger proportion than are ever met with in a gas engine, and the presence of products of combustion in an engine cylinder will therefore not affect the pressures and the rate of burning to the extent indicated in these experiments

13. As has been pointed out in §2 these experiments were undertaken in order to determine whether the presence of a gas like CO_2 which absorbs radiation of the kind emitted by an exploded mixture of coal-gas and air would check the large loss of heat which goes on by radiation. It was found that although the total emission was reduced such reduction was entirely due to the lower gas temperatures developed on explosion. Indeed, when the rates of emission from the CO_2 and the nitrogen mixtures are compared at the same gas temperatures the emission from the former in the final stages of explosion and in the initial stages of cooling† is far greater than that from the latter.

These experiments seem to indicate that the vibratory degrees of freedom of the inert CO_2 molecules very rapidly absorb energy from the freshly-formed molecules which are known to possess at the moment of formation a considerable excess of vibratory energy over and above the amount which they would possess under equilibrium conditions corresponding to the gas temperature.‡ Probably energy is given to the vibratory degrees of freedom of the inert CO_2 molecules during collision with the freshly-formed molecules as well as by the absorption of radiation emitted by these molecules. Such a hypothesis would throw considerable light on the reasons for the slower rate of development of pressure in the gaseous mixtures diluted with CO_2.

* The total heat of combustion of the coal-gas originally present in this mixture was about 16,400 calories: the loss of heat by radiation during this period is therefore of the order of 1,640 calories.

† It may amount to as much as 20 per cent., or even more, of the heat of combustion of the coal-gas originally present in the vessel.

‡ This experiment was suggested to the author by the late Professor B. Hopkinson.

§ At any rate, when CO_2 is present in large quantities.

* If, as often happens, the products of combustion contain a fraction of uncombined gas, this statement will obviously require amendment.

† This, of course, is the most important epoch from the gas engine point of view, for it is mainly in this epoch that the heat loss occurs.

‡ See Phil. Trans. Roy. Soc., A, vol. cxi, page 381.

BURNT EARTH CONCRETE, WITH IRON AND WOOD REINFORCEMENT.

By L. P. HODGE, Assoc.M.Inst.C.E.

THE substitution of burnt earth for stone in concrete has no doubt received some attention in alluvial countries where stone is scarce and transport costly, but engineering literature contains very little, if any, information on the subject. The same remark applies to "ligno" concrete, *i.e.*, that in which wood is substituted for iron reinforcement. An article on "Some Tests on Ligno Concrete," by C. A. M. Smith, M.Sc., in ENGINEERING of December 16, 1910, drew attention to its possibilities, but as long as iron and mild steel were easily obtainable at fair prices, engineers preferred to use them in preference to wood. Owing, however to the large increase in the cost of imported metal due to the war, and to the difficulty of getting it, ligno concrete is now likely to come to the fore where conditions are favourable to its employment. The author ventures therefore to hope that the following tests of burnt earth concrete beams with both iron and wood reinforcement, and their successful employment in piles and abutment slabs, will be of practical assistance to those who may be desirous of employing similar materials.

Burnt Earth Concrete.—The earth burnt in British Guiana is generally the ordinary coast alluvium, the surface analysis of which is as follows compared with London brick clay:—

Constituents.	Demerara Clay.	London Brick Clay.
Silica crystalised	19·648	49·5
Silica combined	34·728	34·3
Alluvium	11·950	7·7

For reinforced concrete only clinkers were used, and after breaking they were screened through a 1-in. mesh and retained on a ¼-in. mesh, being thoroughly washed during the retention screening. The mixture was 1 : 2 : 4. The Portland cement used throughout was supplied to British standard specification. Sufficient for 12 neat briquettes was taken from three barrels.

The average breaking stress at 6 days was 428·5 lb. and at 28 days 508·5 lb. The average increase was, therefore, 18·7 per cent., or slightly under the 20 per cent. required by standard.

Assumed Resistance to Compression.—As the bridges for which these experiments were undertaken were urgently required, it was desirable to test the beams not more than seven days after casting. To determine the probable ultimate compression of the burnt earth concrete at that time, so as to approximately apportion the material in the test beams, the author employed the formula deduced by Mr. Edwin Thatcher from his experiments for Mr. George A. Kimball, chief engineer of the Boston Electric Railway Company ("Trautwine," nineteenth edition, page 1106, paragraph 35).

$$S = M - N \times$$

where:

S = ultimate compressive strength in pounds per square inch.
X = number of parts of sand to 1 of cement.
M and N = values as below:

Age 7 Days.	1 Month.	3 Months.	6 Months.
M = 1,800	3,100	3,820	4,900
N = 200	350	460	600

The concrete being 1 : 2 : 4.

$S = 1{,}800 - (200 \times 2) = 1{,}400$ lb. per square inch. The author decided to limit the safe stress at 7 days to 300 lb. per square inch = F of S, 4⅔.

Iron Reinforcement.—This consisted of unmarked rod iron, marked rods being unobtainable owing to the war. Its safe tensile strength was assumed throughout as not exceeding 5 tons per square inch.

Wood Reinforcement.—This was our indigenous greenheart (Nectandra rediocl) of which the ultimate resistance to tension is stated to be for ordinary quality, 8,800 lb. per square inch. (Rivington's "Notes on Building Construction," Part IV, Table I.) Its safe tensile stress was assumed at one-fifth = 1,760 lb. per square inch. The ratio of substitution became therefore:

		Lb.	
Iron per square inch 5 tons ...	=	11,200	= 6·4
Greenheart per square inch ...	=	1,760	

The first experiments were made with sawn scantling which had not been soaked in water. Surface cracks developed in every case and thence, save in Experiment B, the wood reinforcement was immersed for 24 hours immediately before the beam was cast. The increase of weight due to absorption was as follows:—

Absorption of Water by Sawn Greenheart in 24 Hours.

Dimensions of Specimen.	Weight before Immersion.	Weight After Immersion.	Increase, per cent.	Absorption per Sq. Ft. of Area Immersed.
	Lb.	Lb.		Lb.
12 ft. by 3 in. by 2 in. (used in experiment D)	31·0	33·5	8·06	0·248
Two pieces, each 5 ft. by 2 in. by 1 in. (used in experiment F) ..	8·0	9·5	18·75	0·298
Three pieces, each 5 ft. by 2 in. by ½ in. (used in experiment H) ..	6·5	9·0	38·46	0·399

From the above table it is evident that, as might be expected, the absorption of small sections very much exceeds that of large ones, being governed very largely by the surface area immersed.

Tests.—Two piles, two beams and four concrete planks having been designed in accordance with the preceding data, of ferro concrete and ligno concrete,

respectively, were tested as beams, with the results shown graphically on the accompanying diagram. The following is a digest of the tests, the diagram being lettered to correspond.

DIGEST OF EXPERIMENTAL TESTS.

(CONCRETE OF BURNT EARTH 1 : 2 : 4 THROUGHOUT.)

A. *Ferro Concrete Pile.*—A pile, 25 ft. long by 12 in. by 12 in., reinforced with five rods of ¼-in. round iron, was supported at 10 ft. clear span, eight days after casting, and loaded with a distributed load up to 7,749 lb., or about half its estimated distributed safe load at that time, regarded as a continuous beam. It stood this test without taking a permanent set (see diagram A), and was subsequently transported 8 miles by dray, and successfully driven a month after casting.

B. *Ligno Concrete Pile.*—A similar pile, but reinforced with two bars of 2 in. by 2 in., and two bars of 2 in. by 3 in. greenheart in lieu of iron, was similarly supported and loaded at eight days, up to 7,755 lb., or about half its estimated distributed safe load at that time, regarded as a continuous beam, remaining thereunder for three weeks. Slight cracks appeared after loading, due probably to the greenheart not having been immersed before being placed in the concrete, but all deflection disappeared on removal of the load. Unfortunately, this pile was allowed to project too far beyond the dray during transit, and the elasticity of the greenheart, aided probably by lack of adhesion, due to the cause already stated, caused it to crack up in transport. A fresh pile was cast *in situ*, utilising the same reinforcement after soaking it in water for 24 hours, and it drove as well, and is continuing to give as satisfactory results, as the ferro concrete ones.

C. *Ferro Concrete Beam.*—A ferro concrete beam, 12 ft. by 6 in. by 6in., reinforced with two ⅜ in. rods, was tested at seven days, ends supported, at 10 ft. span. The safe distributed load of this beam was calculated at 1,371 lb. at that time. It collapsed under 2,249 lb., the tension rods being reduced by about ⅛ in. diameter.

D. *Ligno Concrete Beam.*—A similar beam, but reinforced with a 3-in. by 2-in. greenheart scantling, collapsed under 2,039 lb., by the failure of the reinforcement in tension. This beam failed with only 10 per cent. less load than its ferro concrete competitor.

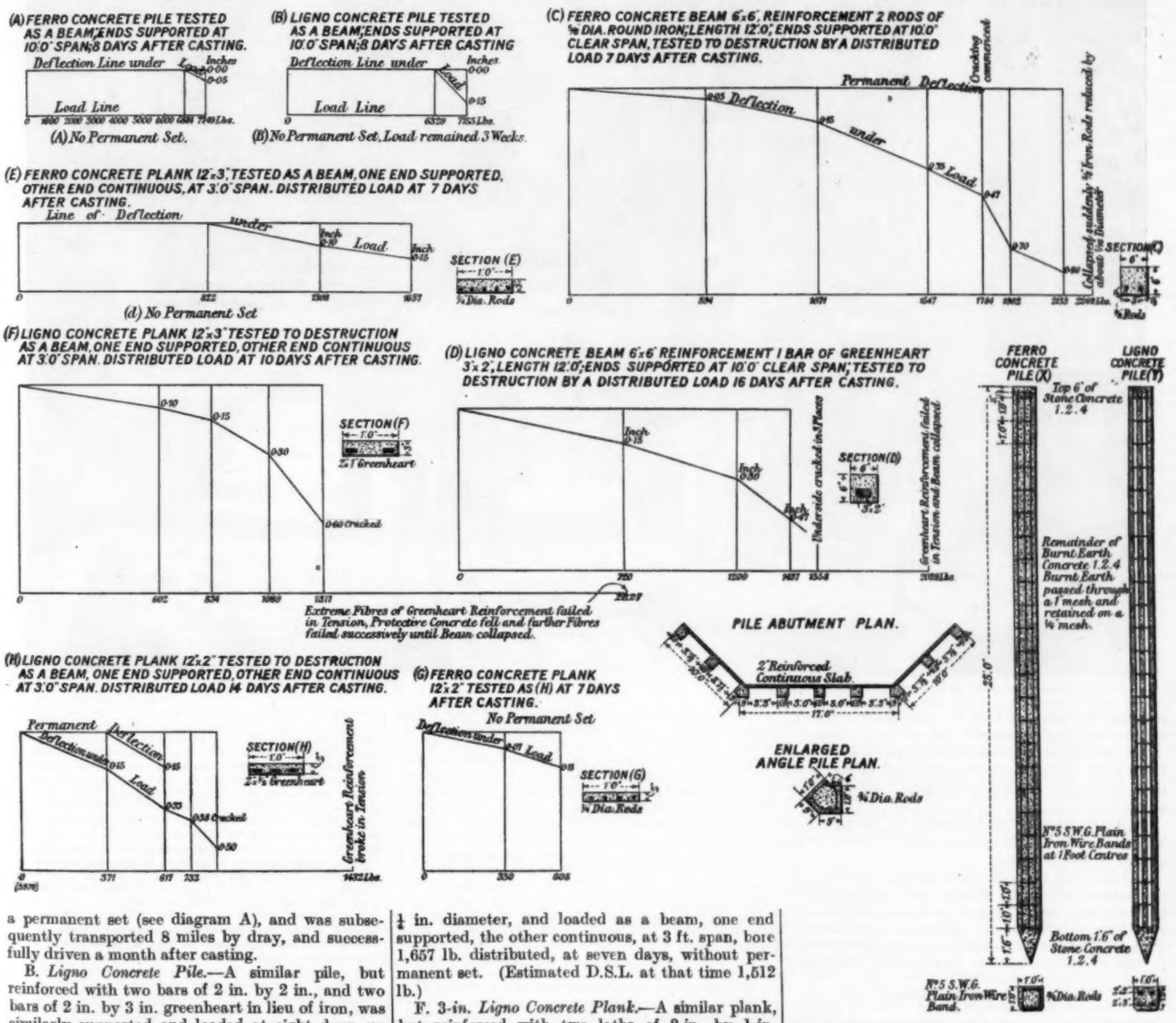
E. 3-*in. Ferro Concrete Plank.*—A ferro concrete plank, 12 in. by 3 in., reinforced with five rods of ½ in. diameter, and loaded as a beam, one end supported, the other continuous, at 3 ft. span, bore 1,657 lb. distributed, at seven days, without permanent set. (Estimated D.S.L. at that time 1,512 lb.)

F. 3-*in. Ligno Concrete Plank.*—A similar plank, but reinforced with two laths of 2-in. by 1-in. greenheart, similarly supported at the same span, broke with a distributed load of 2,627 lb., at ten days, owing to the failure of the reinforcement. (Estimated D.S.L. at that time 1,955 lb.)

G. 2-*in. Ferro Concrete Plank.*—A ferro concrete plank, 12 in. by 2 in., reinforced with four rods of ¼ in. diameter and loaded as a beam one end, supported the other continuous, at 3 ft. span, bore 605 lb. distributed at seven days without permanent set. (Estimated D.S.L. at that time 700 lb.)

H. 2-*in. Ligno Concrete Plank.*—A similar plank, but reinforced with two lathes of 2 in. by ⅛-in. greenheart, similarly supported, at the same span, broke with a distributed load of 1,432 lb., at 14 days, owing to the failure of the reinforcement. (Estimated D.S.L. at that time 733 lb.)

Practical Tests.—Seventy-two of the piles shown in the diagram (71 of ferro concrete and 1 of ligno concrete) were driven about 17 ft. through clay after one month from casting. None failed, or had to be re-cast, save the first experimental ligno concrete pile previously referred to. There are nine such piles in each bridge abutment (*vide* abutment plan), and they carry a maximum motor load of 2 tons per axle on an 8-ft. wheel base, over a maximum span of 22 ft. They were driven with an 18-cwt. ram, the tops being protected by a canvas pillow, 10 in. square by 4 in. deep, stuffed with sawdust, upon which was superposed a hardwood dolly, 18 in. long by 12 in. by 12 in., to take the impact.


(A) FERRO CONCRETE PILE TESTED AS A BEAM, ENDS SUPPORTED AT 10'0" SPAN; 8 DAYS AFTER CASTING.
Deflection Line under Load
Load Line
(A) No Permanent Set.
(B) LIGNO CONCRETE PILE TESTED AS A BEAM; ENDS SUPPORTED AT 10'0" SPAN; 8 DAYS AFTER CASTING
Deflection Line under Load
Load Line
(B) No Permanent Set, Load remained 3 Weeks.
(C) FERRO CONCRETE BEAM 6"x6", REINFORCEMENT 2 RODS OF ⅜ DIA. ROUND IRON; LENGTH 12'0"; ENDS SUPPORTED AT 10'0" CLEAR SPAN, TESTED TO DESTRUCTION BY A DISTRIBUTED LOAD 7 DAYS AFTER CASTING.
Cracking commenced
Permanent Deflection
Deflection under Load
Collapsed suddenly ⅜ Iron Rods reduced by about ⅛ Diameter
SECTION (C)
⅜ Rods
(E) FERRO CONCRETE PLANK 12"x3", TESTED AS A BEAM, ONE END SUPPORTED, OTHER END CONTINUOUS, AT 3'0" SPAN. DISTRIBUTED LOAD AT 7 DAYS AFTER CASTING.
Line of Deflection under Load.
SECTION (E)
½ Dia. Rods
(d) No Permanent Set
(F) LIGNO CONCRETE PLANK 12"x3" TESTED TO DESTRUCTION AS A BEAM, ONE END SUPPORTED, OTHER END CONTINUOUS AT 3'0" SPAN. DISTRIBUTED LOAD AT 10 DAYS AFTER CASTING.
SECTION (F)
2 of Greenheart
0·60 Cracked.
(D) LIGNO CONCRETE BEAM 6"x6" REINFORCEMENT 1 BAR OF GREENHEART 3"x2", LENGTH 12'0"; ENDS SUPPORTED AT 10'0" CLEAR SPAN; TESTED TO DESTRUCTION BY A DISTRIBUTED LOAD 16 DAYS AFTER CASTING.
Underside cracked in 3 Places
Greenheart Reinforcement failed in Tension and Beam collapsed.
SECTION (D)
3"x2"
Extreme Fibres of Greenheart Reinforcement failed in Tension, Protective Concrete fell and further Fibres failed successively until Beam collapsed.
(H) LIGNO CONCRETE PLANK 12"x2" TESTED TO DESTRUCTION AS A BEAM, ONE END SUPPORTED, OTHER END CONTINUOUS AT 3'0" SPAN. DISTRIBUTED LOAD 14 DAYS AFTER CASTING.
Permanent Deflection
Deflection under Load
SECTION (H)
2 of ½ Greenheart
0·38 Cracked.
Greenheart Reinforcement broke in Tension
(G) FERRO CONCRETE PLANK 12"x2" TESTED AS (H) AT 7 DAYS AFTER CASTING.
No Permanent Set
Deflection under Load
SECTION (G)
¼ Dia. Rods
PILE ABUTMENT PLAN.
2" Reinforced Continuous Slab.
ENLARGED ANGLE PILE PLAN.
¾ Dia. Rods
FERRO CONCRETE PILE (X)
LIGNO CONCRETE PILE (Y)
Top 6" of Stone Concrete 1.2.4
Remainder of Burnt Earth Concrete 1.2.4 Burnt Earth passed through a 1" mesh and retained on a ¼" mesh.
N°5 S.W.G. Plain Iron Wire Bands at 1 Foot Centres
Bottom 1'6" of Stone Concrete 1.2.4
N°5 S.W.G. Plain Iron Wire Band.
¾ Dia. Rods

The reinforced concrete at the back of the piles was cast as a 2-in. continuous slab, the spacing of the ¼ in. diameter reinforcement lessening from 3 in. centres at the bottom, where the average depth of clay to be sustained is 8 ft., to 6 in. at the top, where the maximum depth is about 2 ft. below the crown of the road surface.

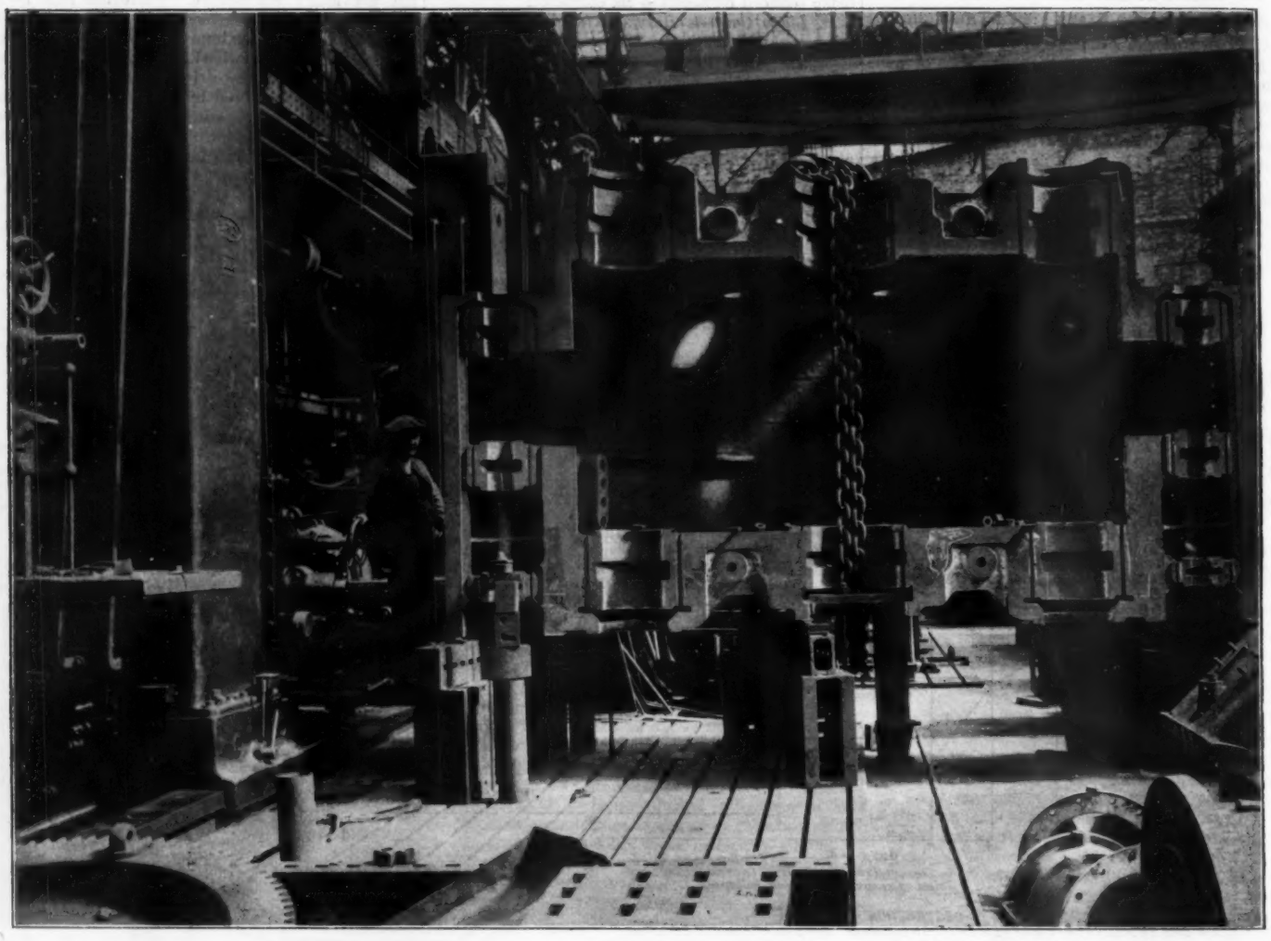
Conclusions.—From his experiments and practice the author arrives tentatively at the following conclusions:—

1. Well burnt earth can be substituted for stone in concrete with safety and advantage when the cost of stone is prohibitive.

2. Hard wood can be substituted for iron or steel reinforcement with advantage in fairly large sections when, as is the case in British Guiana at

HORIZONTAL HIGH-SPEED BORING, DRILLING, TAPPING, & STUDDING MACHINE.

CONSTRUCTED BY MESSRS. G. AND A. HARVEY, ENGINEERS, GLASGOW.



present, the cost of iron is prohibitive. But in sections of small depth, the cost of converting the wood into thin strips, and the difficulty of so placing them as to get sufficient tension, and at the same time sufficient surface protection, outweigh its advantage.

3. Wood so employed should be immersed in water for at least 24 hours immediately before being placed in the concrete.

4. The most suitable wood having regard to its ultimate resistance to tension, and particularly to its uniformity, would appear to be greenheart (*vide* Rivington's "Notes on Building Construction," Part IV, Table I), the available quantity of which in British Guiana will be inexhaustible for many years.

HORIZONTAL HIGH-SPEED BORING, DRILLING, TAPPING, AND STUDDING MACHINE.

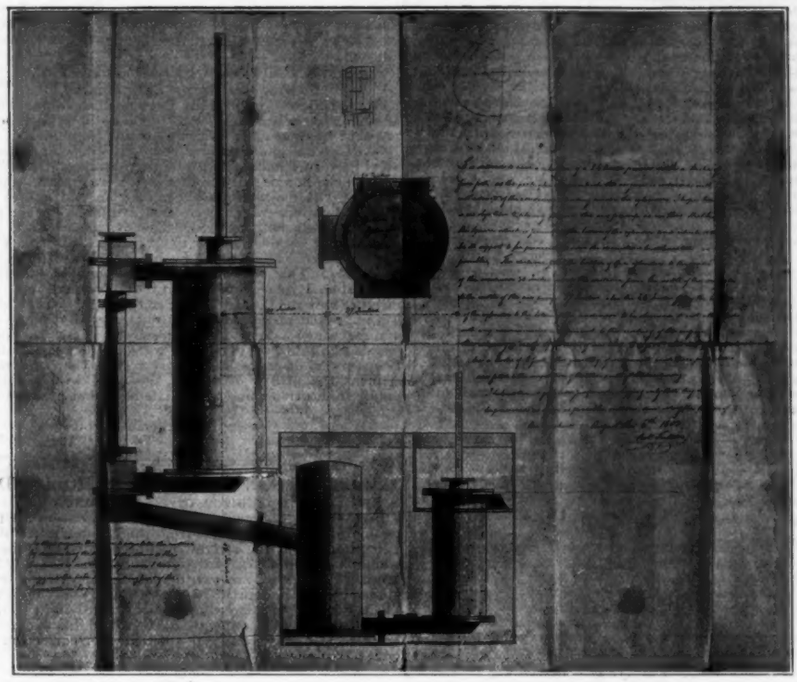
With the introduction of high-speed drills and taps, it is necessary to have machines to withstand the tear and wear of high speed and still retain their ease of manipulation. The machine illustrated above, constructed by Messrs. G. and A. Harvey, Glasgow, is fitted up at the engine works of Messrs. Scotts' Shipbuilding and Engineering Company, Limited, Greenock. The machine is of the horizontal type, and is capable of high-speed boring, drilling, tapping and studding. It is fitted with double columns, which are independent, and allow both spindles to be brought into action on one piece of work when necessary, or each spindle to be used on separate pieces. The machine is specially adapted for drilling and tapping, the double gear on the saddle being so arranged that the high speed for drilling is rapidly changed, to a slower and more suitable speed for tapping, at the same time giving increased power; after reversing, the tap can be withdrawn at the higher speed if desired. Each of the spindles is 4 in. diameter, with a feed traverse of 3 ft. and a vertical range of 13 ft., while the extreme distance between the spindles is 18 ft. 6 in. The standards traverse on a sliding base 6 ft. 10½ in. wide. Upon the work table which is 21 ft. in length by 9 ft., there is shown in the illustration the bottom half of one of the double reduction gear cases for a twin screw merchant liner, fitted with Brown-Curtis turbines at present being constructed by Scotts' company. The operating gear for the machine comprises two motors of the B.T.H. type, variable speed, 15 h.p. each, for 250 volts, D.C., with two starters of the Brooke-Hirst type.

Swansea Tinplate Shipments.—Last week's shipments of tinplates from Swansea amounted to 22,223 tons as compared with 83,971 tons in the previous week, and 3,933 the corresponding week a year ago. The material received from works for the three weeks was 77,931 tons, 54,818 tons and 9,186 tons.

Bread Baking by Electricity.—The Paris journal *L'Industrie Electrique* gives information on the progress recently made in Switzerland in the installation of bread baking ovens heated electrically, the current being generated by water-power. It quotes among other figures the following:—For baking 100 kilogrammes of bread, the coal consumption in the ordinary ovens is from 35 to 50 kilogrammes, and 16k. in the large steam-heated ovens. The required electric energy for baking the same quantity is from 45 to 50 kilowatt-hours.

The Dellwik-Fleischer Trigas Process.—Some years ago the Dellwik-Fleischer Watergas Company, of Frankfurt, modified its furnaces for the combustion of bituminous coal in such a way that the blow was directed from the middle of the producer downward, and thus from the zone intermediate between distillation and gas-making layers downward across a fire bridge and through the coking zone. The watergas produced in the lower layers was thus to be carried with sufficient heat into the coal above to gasify the volatile product, while the air was excluded. It had proved very difficult to maintain the desired high temperatures with indirect heating in a retort, and hence this direct heating was adopted; but there was first trouble with smoke. The further object of this new "trigas" process was the production of a low-temperature tar and the recovery of the ammonia. The first trials on a somewhat large scale were made in Vienna with lignite in a plant of three producers, of an aggregate capacity of 150 cub. m. of gas per hour. Further experiments in a plant of ten times this capacity were then made by E. Dolensky, director of the company, and by A. Pott, manager of Mathias Colliery, near Essen. When this latter plant was described in the *Journal für Gasbeleuchtung* of May 17 last, it had been running for eleven months, with one interruption at the end of the first five months for cleaning the furnace of clinker. Various fuels were used on revolving grates, comprising a coal with 11 per cent. of ashes and 5·5 per cent. of moisture, a lignite with 55 per cent. of water, peat, &c. The temperature was so regulated as to produce a gas of about 3,000 kg. calories. The gas yield was then 1·8 cub. m. per kilogram of fuel, and the gas consisted of 51·5 per cent. of hydrogen, 5·5 per cent. of an ethane, 24 per cent. of CO, 13·3 per cent. of CO_2, and less than ½ per cent. of oxygen and sulphur. When coal alone was used the calorific value of the coal rose to 3,875 calories, but the tar production was not so satisfactory at the higher working temperature. The tar is described as port-wine red in colour, density 1·04 per cent. at 15 deg. C. and as completely soluble in benzene. It is free of naphthalene, contains about 40 per cent. of phenols and rosin, and can yield (on distillation in vacuo) 27 per cent. of spindle oil, 32·5 per cent. of heavier lubricating oil, 33 per cent. of solid paraffin and 26 per cent. of pitite. A mixture of coal and 25 per cent. of lignite gave 6 per cent. of this low-temperature tar. The results are regarded as very satisfactory, though there is still trouble sometimes with the caking of the fuel, and it is hoped that the problem of using bituminous coal in watergas generators has been solved after many years of experimenting.

THE ENGINE OF THE STEAMER "CLAREMONT," 1803.



IN connection with the James Watt Centenary to be celebrated this month the annexed reproduction of a photograph of the original drawing of the engine of the Claremont constructed by Boulton and Watt in 1803, will be examined with interest.

The Claremont was a steamer constructed by Robert Fulton for running on the East Hudson River between New York and Albany. The engine was ordered by him from Boulton and Watt, and the drawing which we reproduce appears to be one which was sent to Watt by Fulton with his comments and instructions. The writing is quite plain in the photograph, but is not legible in our half-tone block, and we therefore subjoin a copy of the notes written on the drawing. They are as follow :—

Short note on left-hand side of drawing :

"In this engine the valve to regulate the motion by diminishing the passage of the steam to the condenser is not necessary. Hence I have designed the tube A as making part of the lower steam box."

Note on right-hand side of drawing :

"It is desired to have a cylinder of a 24 horse-power with a stroke of four feet, as the particular use for which this engine is intended will not admit of the condenser standing under the cylinder, I hope there is no objection to placing it aside the air pump, as in this sketch. The square which is formed on the bottom of the cylinder and which is to be its support to be preserved as near the dimensions delineated as possible. The distance from the centre of the cylinder to the centre of the condenser, 30 inches, and the distance from the centre of the condenser to the centre of the air pump, 37 inches. Also the 46 inches from the bottom of the cylinder to the bottom of the condenser to be observed if it is not attended with any inconvenience or detriment to the working of engine. This drawing is made by a scale of one inch to a foot. The air pump has a stroke of 2 feet. This quantity of movement and these proportions are fitted to the composition of the other parts of the machinery."

"I submit them to your better judgment, begging only that they may be preserved as near as possible without diminishing the power of the machine."

August 6th, 1803,

(s'd) ROBERT FULTON.

TIPPED TOOLS : ERRATUM.—In the paragraph dealing with "Fluxio" welding compound for tipped tools, which appeared on page 277 of our last issue, there was a small printer's error which should be corrected. It was stated that the shank of a tool required to be covered on the tip seat with a layer of compound 1½ in. thick. This should read $\frac{1}{12}$ (one-twelfth) of an inch.

INDUSTRIAL NOTES.

MR. M. O. LEIGHTON, Chairman of the Engineers, Architects and Constructors' Conference on National Public Works, writing from Washington to the Editor of *Engineering News-Record*, New York, says he heard something about engineers the other day from a great man—an acknowledged statesman, a high-minded politician and a keen observer of people and events. His name, if he were permitted to tell it, would surprise every reader. The talk was about the project for a National Department of Public Works, and the statesman's words were as follows :—

"Your task is appalling. You have been elected to lead engineers into a political reform. They are the most unresponsive citizens that we have. Your organisation has a praiseworthy purpose, but if it were sponsored by almost any other group of reputable men than engineers there would be more promise of success. If your organisation succeeds, I believe you will find that it will not be the engineers who have carried it through. Their aloofness and indifference to all matters outside their own professional sphere are among the unexplainable things in our political life."

Mr. Leighton adds in his comments that the statement hurt. He questions how many other public men have the same opinions. As it came from a high authority not given to loose talk, it seemed wise, he concludes, to pass it on.

We should advise Mr. Leighton to take the statement in question as a compliment to engineers. The statesman he interviewed cannot but recognise that any one engineer or metallurgist has done greater service to the world than hosts of politicians, and he may be somewhat jealous at the engineers' achievements. The profession of an engineer absorbs him so completely that he has no leisure to devote to politics and to mere talk. On the other hand, if engineers could set apart a portion of their long day, and we say "long day" advisedly, to deal with "our political life," then that life would be greatly improved and more real work would be done.

We read in *Revue du Travail*, Brussels, that the 50-hour week commenced to be followed on August 1 ; on March 31, 1920, the week will be of 48 hours.

The monthly report dated August 12, issued by the Steam Engine Makers' Society, gives the membership as 28,000 and the capital as 290,000*l*. The report says there is every sign of war within the country itself, a condition which ought not to be, and will not prevail if every *bona fide* and honest workman puts his shoulder to the task and fully realises his own personal responsibility.

The Court of Arbitration issued last week its awards in a reference by the North-West Engineering Trades Employers' Association, the Clyde Shipbuilders' Association, the Scottish Brass Founders and Finishers Employers' Association, the Scottish Coppersmith Employers' Association, and the Federation of Engineering and Shipbuilding Trades, Clyde District Committee. The questions dealt with arose out of the award No. 2045, August 8, 1918, of the Committee on Production, engineering and shipbuilding trades, Clyde district, on working rules and submarine allowances.

The award of the Court, on the claims that pieceworkers who have worked overtime until 2 a.m. ought to be paid, until the usual stopping time in the morning, their average earnings on piecework in addition to overtime allowance, is that a pieceworker is to be paid, in addition to his actual piecework earnings, an allowance of one-half ordinary time rate for the hours actually worked, and ordinary time rate plus 50 per cent. for the remaining hours. If a day shift employee has commenced work he is entitled, if sent home and asked to return to work the same night on night shift, to receive payment for the first night at overtime rates.

The other awards of the Court regulate the allowances for repair or dirty work, and work on oil ships.

The further findings of the Court are to the effect that a submarine is "near completion" when the batteries have been installed and are ready for charging, and as "closed in" when the shell has been completed. Electricians actually engaged on main motor trials in the main motor compartment are to receive 2*s*. 6*d*. extra per trial, and other tradesmen actually engaged on their own work in the main motor compartment in course of the trials are to receive 1*s*. 6*d*. extra per trial, whether the vessel is running or moored.

An oil ship is a vessel constructed for carrying oil as cargo in bulk. An ordinary tramp steamer carrying oil in her double bottom as fuel is not to be considered an oil ship, but in the event of a ship of this description coming in for repair, having carried oil in her double bottom for fuel purposes, men engaged on repairs of the ship's double bottom are to be paid oil ship's allowances while working in the double bottom, or that part of it where oil has been carried, including shell and tank tops.

The appropriate outworking allowances are to be paid to apprentices, and red leaders are to receive the allowance for "dirty" work. On the claim that, in addition to the outworking allowances, the men concerned are entitled to train fares, the Court made no order, as it did not consider the matter to be one of interpretation of award No. 2045.

In a recent speech on his return from a visit to several important United States shipbuilding yards, including the vast Hog Island establishment, Sir Joseph Davies, K.B.E., the well-known South Wales financier, said at the annual general meeting of the shareholders of Messrs. J. Samuel White and Co., Limited, Cowes, I.W. : "I should like to mention one thing in regard to America, where I have had the opportunity of seeing the shipbuilding there, the old yards and the new yards, and that is that I have come back satisfied that we can always hold our own in shipbuilding, unless a great change is brought about on the other side."

The South Wales Coal Conciliation Board at Cardiff, says *The Yorkshire Post*, have straightened out some complications which had arisen in connection with the agreed addition of 14·2 per cent. to piece workers' rates in compensation for the shorter working day. The workmen alleged that the owners were not carrying out the spirit of the award inasmuch as they were not paying the increased percentages on allowances to make up the minimum wage ; that is to say, the 14·2 is added to all the items on the price list, but when allowances are made to a workman to bring him up to the minimum, the perceptage is not added, and the workmen's representatives argued that it should be, because the men working below the minimum work as hard as do those paid above. After a long discussion, an amicable settlement was reached on the following formula :—

1. All allowances to piece workers on minimum wage are to be subjected to the addition of 14·2, but the allowances should be adjusted in such a way that, with the addition of the 14·2, there is no increase in wages.

2. If the earnings of a piece worker plus the 14·2 are more than the minimum wage, he is entitled to the excess.

The Executive of the Miners' Federation of Great Britain met last Tuesday in London to consider the situation created by the Government's scheme in

regard to the nationalisation of mines. At the close of the meeting, which was presided over by Mr. Robert Smillie, Mr. Frank Hodges, general secretary of the Federation, issued the following statement:—

The Executive met mainly to discuss the decision of the Government with reference to the Majority report of the Coal Commission.

After a full discussion, the following resolution was passed:—

"Being convinced that the Government's scheme is wholly impracticable for the future working of the mines, the Executive Committee recommends the conference of miners' delegates to reject the Government scheme, and records its regret that the Government has no better scheme than the creation of great Trusts to secure the economic well-being of industry.

"We are convinced that the only way to place the industry upon a scientific basis for the purpose of giving the advantage of a maximum production to the community consistent with the maximum economic and social well-being of the miners is at once to introduce the scheme of nationalisation recommended by the Majority of the Coal Industry Commission.

"We do not at this stage recommend the miners to take industrial action to secure the adoption of the Coal Commission Report, but we invite the Trades Union Congress to declare that the fullest and most effective action be taken to secure that the Government shall adopt the Majority report of the Commission as to the future governance of the industry."

Mr. Hodges added that the resolution would be brought before the conference of delegates on the following day (last Wednesday), as a recommendation from the Executive, and the discussion would be open to the Press.

The Government's scheme referred to includes the purchase of mineral rights by the State; the amalgamation of mines in defined areas, with a view to reduce the cost of management and waste; the mines so amalgamated to be controlled by committees containing representatives appointed by the miners; the mines to be overlooked by the State in the interest of the community; the raising of funds for improving the housing of miners.

These conditions, it will be seen, were rejected at Tuesday's meeting, and insistence was laid upon the introduction of nationalisation on the lines of the Majority report of the Sankey Commission.

At Wednesday's special meeting of the Miners' Federation held in London the Government's scheme was rejected and the complete nationalisation of the mines was insisted upon, the meeting carrying unanimously the above resolution passed at Tuesday's meeting.

The Board of Trade has now issued a statement on the weekly coal output, from which we take the following figures:—For the week ending May 31, 4,812,595 tons; for the weeks ending July 19, July 26, August 2 and August 9, 3,893,652 tons, 2,537,954 tons, 3,614,776 tons, and 2,642,895 tons respectively.

As from last Monday, the 1st inst., the restrictions on imports, which had been in force during the war, ceased to be applicable, and all nations can now send their products to the United Kingdom, apart from goods in scheduled key-industries. Among the protected exceptions are dyes, drugs, photographic chemicals, saccharin, optical, scientific and illuminating glass, optical and scientific instruments, gas mantles, magnetos and gauges.

Many trades throughout the country are apprehensive at the keen competition that will ensue.

PERSONAL.—Mr. R. C. Atkinson, Assoc.M.Inst.C.E., A.M.I.E.E., A.M.I.Mech.E., who has for the last seven years held the appointment of superintendent of the Power Station Construction Department of the Yorkshire Electric Power Company, has joined the firm of E. L. Thorp and Co. (late Shepherd and Watney), consulting engineers, of 32, Greek Street Chambers, Leeds. The firm will in future practice under the title of Thorp and Atkinson, at the same address.—Messrs. C. P. Sandberg inform us that on and after September 4, 1919, their London address will be 40, Grosvenor-gardens, London, S.W.1. The cable and telegraphic address will remain as above, but the telephone numbers will be Victoria 6877, 6878 and 6879.—Messrs. John I. Thornycroft and Co., Limited, inform us that Mr. John Smith, late of Messrs. J. Samuel White and Co., Limited Cowes, has been appointed a Technical Director of this company, and General Manager of the shipbuilding and ship repairing work at Southampton, in the place of the late Mr. Callaway.—Mr. C. L. Faulkner, Director of Messrs. Bolling and Lowe, Limited, 2, Laurence Pountney Hill, E.C.4, informs us that Mr. L. Reincke, who had been a principal in the business for 38 years, has retired, and his entire interests have been taken over by Mr. Alistair Doughty, late of Liverpool.—The Brightside Foundry and Engineering Company, Limited, Sheffield, inform us that they have opened a branch office at 29, St. Mary-street, Cardiff, and also at 14, Dale-street, Liverpool.

UNIVERSITY MATHEMATICS FOR ENGINEERS.

TO THE EDITOR OF ENGINEERING.

SIR,—With reference to the letter from your correspondent under "University Mathematics for Engineers" in your issue of the 15th inst., I think he is somewhat mistaken in his assertion that English engineers are misinformed as to the meaning of V in cosh V, sinh V, &c., and that the only fount of knowledge is to be found somewhere not in England.

He says, referring to the analogy between the circular and hyperbolic functions, "but they frequently leave the student to make the erroneous inference that the V in sinh V is numerically equal to the length of the corresponding hyperbolic arc, just as the V in sin V is the length of the circular arc."

Now the V in sin V is only equal to the length of the circular arc when the radius of the circle is unity.

What it really is, is $\int_0^s \frac{d\,s}{r}$ and in the circle this is equal to $\frac{1}{r}\int_0^s d\,s = \frac{s}{r}$, because in the circle the radius is constant.

Your correspondent has chosen a particular case for his illustration of the hyperbola and has thus obtained a result which is somewhat misleading.

Let us apply the method of obtaining the V in sin V to the most general case of a rectangular hyperbola of which the abscissa is the axis, i.e., $x^2 - y^2 = a^2$.

Let $V = \int_0^s \frac{d\,s}{r}$, where r is the radius of the hyperbola (i.e., the distance from the origin to a point on the curve) and we suppose the radius vector to start from the abscissa.

Now
$$d\,s = \left\{1 + \left(\frac{d\,y}{d\,x}\right)^2\right\}^{\frac{1}{2}} d\,x$$

$$y = (x^2 - a^2)^{\frac{1}{2}} \text{ and } \frac{d\,y}{d\,x} = \frac{x}{(x^2 - a^2)^{\frac{1}{2}}}$$

$$\therefore\ d\,s = \frac{\sqrt{2\,x^2 - a^2}}{\sqrt{x^2 - a^2}}\,d\,x$$

also
$$r^2 = x^2 + y^2 = x^2 + x^2 - a^2 = 2\,x^2 - a^2$$

$$\therefore\ r = \sqrt{2\,x^2 - a^2}$$

$$\text{and } \frac{d\,s}{r} = \frac{d\,x}{\sqrt{x^2 - a^2}}.$$

Let x_1 be the abscissa of the end of the arc, and a will be the abscissa of the starting point, then

$$V = \int_a^{x_1} \frac{d\,x}{\sqrt{x^2 - a^2}}$$

$$= \Big[\log_e (x + \sqrt{x^2 - a^2})\Big]_a^{x_1}$$

$$= \log_e \frac{x_1 + \sqrt{x_1^2 - a^2}}{a}$$

If we now denote by x the abscissa of any point on the hyperbolic arc

$$V = \log_e \frac{x + \sqrt{x^2 - a^2}}{a}$$

and
$$e^V = \frac{x}{a} + \frac{\sqrt{x^2 - a^2}}{a}$$

$$\therefore\ \frac{x^2 - a^2}{a^2} = \left(e^V - \frac{x}{a}\right)^2 = e^{2V} - \frac{2\,x}{a}\,e^V + \frac{x^2}{a^2}$$

$$\therefore\ \frac{2\,x}{a}\,e^V = e^{2V} + 1$$

whence
$$\frac{x}{a} = \frac{e^V + e^{-V}}{2} = \text{cosh V}$$

Now in the circle of radius r, $\frac{x}{r} = \cos V$ where V is the corresponding angle, there is therefore a complete analogy between the hyperbolic and trigonometric functions in their relation to the hyperbola and circle respectively.

Similarly it may be shown that in the hyperbola $\sinh V = \frac{y}{a}$ corresponding to $\sin V = \frac{y}{r}$ in the circle.

Also the area of a circular sector is $\frac{1}{2}\,r^2\,V$ where r and V are radius and angle respectively, in the hyperbola the area of the hyperbolic sector between any radius vector (dealing with the first quadrant only for simplicity) and the arc, and the abscissa is $\frac{1}{2}\,a^2\,V$ where V is the distance from origin to vertex and V is $\log_e \frac{x + \sqrt{x^2 - a^2}}{a}$.

Of course when r and a are each unity, as in the examples chosen by your correspondent, the respective areas are each $\frac{1}{2}\,V$; but this is a mere coincidence, and quite obscures the very striking analogy between the hyperbolic and circular functions.

I have taken the liberty of writing the above because students would be led to believe by your correspondent that there was no such connection between the hyperbola and hyperbolic functions as there is between the circle and the circular functions, whilst in fact the analogy is most remarkable.

In conclusion, I may say that the derivation of the hyperbolic functions given above is very ably demonstrated in a small book on the Differential and Integral Calculus, by Edwin Edser, A.R.C.S., F.Ph.S., published in 1901, so I am quite at a loss to understand where your correspondent got his opinion of the abysmal ignorance of English writers and teachers on this particular subject.

Yours faithfully,
WM. HUGHES.

50, Bellevue-road, Southampton, August 31, 1919.

THE PATENT OFFICE LIBRARY.

TO THE EDITOR OF ENGINEERING.

SIR,—In pre-war times the Patent Office Library, one of the best in its line, was probably unique in one respect: it was open every weekday from 10 a.m. to 10 p.m. That enabled busy people to keep up in technical literature and to continue their studies after office and college hours, and the facilities were greatly appreciated. The main war has come to an end. Most of the publications which were not available during the war can again be consulted. The replenished staff are as obliging as ever. But the Library still closes at 5 p.m., and the hours are only to be extended to 8 p.m., it appears. That is a concession to economy of questionable value, I venture to submit. Old readers will remember how the Library, after a temporary rush about 6 p.m., when people looked in on their way home, remained almost deserted till nearly 8 p.m. To busy people the late evening hours were the most valuable. Economy is, of course, imperative. But the restriction cripples the utility of one of the most widely useful public institutions, and very little is probably saved by it.

Respectfully yours,
"READER."

AIRCRAFT CONSTRUCTION IN HOLLAND.

TO THE EDITOR OF ENGINEERING.

SIR,—I feel obliged to draw your attention to the wrong information you got from the London and China Telegraph about the aircraft exhibition in Amsterdam, which is communicated in your issue of Friday, July 25, 1919. In Holland are two aeroplane factories, one is named "Trompenburg" in Amsterdam, and the other "van Berkel" in Rotterdam, while a third is in course of construction, and is intended to be managed by Fokker. Hoping you will publish this correction in your next issue.

I am, Sir,
A. C. METZELAAR,
Technical Service, Royal Packet Steam Navigation Company, Scheepvaarthuis, Amsterdam.

Amsterdam, August 28, 1919.

THE SOCIAL STATUS OF OFFICERS OF THE PUBLIC WORKS IN INDIA.

TO THE EDITOR OF ENGINEERING.

SIR,—It is very important for the recruit who joins Government service in a foreign country to know exactly what he is coming to. A large number of young men have accepted service in India with but the flimsiest notions of what the pay offered is worth or what are the social advantages or disadvantages of the service they choose. In England there prevails the most fantastic ideas of the amenities of life in India, and none know of the unfortunate dissensions which are a canker in the social relations of the various services in the country.

In past times India was a place where social amenities were an attraction to the youth of England who sought an outflow for their energies by enlisting in the services under the control of the Government of India. The legend still serves to lure and snare the unwary young men who live to curse the day they were foolish enough to come to India.

The newness of things and the usual welcome extended to a fresh arrival, will serve to hoodwink him and to hinder him from making a correct valuation of his surroundings. Discretion comes with years, and when the scales drop from his eyes, it is generally too late to retract. The recruit of five years' ago is becoming specialised in his branch, and the forfeiture of a period of service for pension is not undertaken without considerable hesitation. If a man is married, it becomes exceedingly difficult for him to try fresh ventures.

The public services in India have a record of scrupulous devotion to duty which may well be envied by the services of many other countries, and not a little of the facility with which the wheels of the administration have revolved in the past has been due to the smooth relations between officials of social equality ready to co-operate. The above described blessed state of affairs has passed away, and the social status of the officers of the various departments is no longer what it used to be.

The Government, which is in the hands of the Indian Civil Service, has by a gradual process subordinated the other departments, and they have now the pleasure arrogantly to look down upon the members of the other departments. Most of the remunerative posts which befell during the war were distributed by the Indian Civil Service amongst themselves.

The difference between the Indian Civil Service and the other departments is not well realised in England; for example, a resolution in Parliament standing on the paper on May 22, 1919, has the expression "various European civil services in India."

An expression like this misleads, but it indicates the general idea in England of service in India. There is only one Indian Civil Service, the other branches or departments being the police, public works, education, forests, telegraphs, &c.

The prospects of the Indian Civil Service are used

advisedly to entice candidates to the other departments, and it cannot be too widely known among possible candidates to these other departments how great is the gulf whch separates the Indian Civil Service from the other departments.

The discrepancy between the rates of emoluments of officers of the same length of service amounts to 50 per cent. or over in favour of the I.C.S., and the more favourable leave allowances, large pension and family pension, are such as to make the pay of the Indian civil servant much more to him than is correspondingly the pay of a member of the other departments. Such favourable preponderance of emoluments of one service has the result of isolating it; another result is the dissatisfaction of the other services at the preferential treatment accorded to the one.

The officers of all the services are doing as much work, and equally good work, as the officers of the I.C.S., and they deserve to be treated with equal consideration in their emoluments. The social status of the services would then be equalised, and the administration as a whole would be benefited.

I am, Sir, yours truly,

AN EXECUTIVE ENGINEER.

AN INVESTIGATION OF THE FLOW OF WATER ENTERING A CANAL FROM A RIVER.

TO THE EDITOR OF ENGINEERING.

SIR,—The water entering a canal from a river is either controlled by a head sluice, or enters through an open head; the phenomenon usually met with in both cases is the formation of silt deposit in the form of a wedge, the deposit being greatest near the sluice and gradually decreasing to nothing a considerable distance down the canal. When the water enters the canal through a sluice there is another phenomenon, called "Back-lash," which occurs close to the sluice. The depth of the silt deposited in the shape of a wedge increases when the river is in flood, and decreases as the flood subsides. Allowing that the surface fall in the canal and the discharge through the head sluice are constant, the velocity of the water entering the canal will increase as the flood in the river rises.

After the silt has been deposited, the wetted sectional area increases from the sluice down stream and the velocity, therefore, decreases as the wetted sectional area increases or, in other words, there is an excess of velocity above the normal canal velocity gradually decreasing in amount as the water flows down the canal.

Actual velocity readings also seem to show that that is the case, as is shown by the following extract from Hydraulics, with Tables by Mr. E. S. Bellasis, M.Inst.C.E., chapter VI, art. 13:—

"The results of over 100 discharges observed near the head of a large canal in India, when arranged into groups according to the depth of silt in the canal, show the average value of N to be 0·025 when there is little or no silt, but 0·013 when the depth of silt is from 0·5 ft. upwards."

As it seems evident that there is an excess of velocity after a deposit has taken place, it is necessary to find the reason for the excess. The excess could hardly be caused by the deposit of silt, and the only other change of conditions is the increased velocity of the water entering the canal through the sluice, due to the flood in the river. It seems quite natural that the water entering the canal at a higher velocity than the normal canal velocity should create an excess of velocity in the canal, and that the excess velocity, thus caused, should gradually decrease as the water flowed along the canal. It is also natural that the excess of velocity would be greater when the velocity through the sluice is greater. In the absence of any other possible reason for the excess velocity in the canal, it may be safely said to be due to the excessive velocity through the sluice.

Now suppose no silt was carried by the river water, there does not seem to be any reason why the water, entering the canal during a high flood, should flow in any manner different than if silt were mixed with the water; consequently the water would flow in the canal with a velocity in excess of the normal canal velocity, and this excess would gradually decrease as the water flowed down the canal. The water flowing with this excess of velocity cannot possibly fill the whole wetted sectional area, and naturally flows on the surface, as this is the path of least resistance. It would spread out on the surface until the banks prevented further spreading. The result of this action is that the whole wetted sectional area is not occupied by the main stream of water and is available for a deposit of silt, if the water entering the canal brings silt with it.

It might seem, at first sight, that the wedge of water that occupies the space between the main stream of water and the bed would flow down stream under the action of gravity, but the flow of the water will depend upon the pressures which, according to Bernouilli's theorem, will be least where the velocity is greatest, consequently there would be a tendency for the water to flow along the bed towards the sluice and a tendency for a return current close to the main current. This current is very slight, but its effects can be observed in clear water.

It would take too much space to give in detail, reasons for the decrease of the excess of the velocity, caused by the water flowing at high velocity through the sluice, but the following may give a rough idea. The water entering through the sluice flows in non-sinuous motion, and when it spreads out on the surface and is contained by the sides of the canal, turbulent motion is set up, which is evident from the eddies or puffs that come to the surface. The force of the puffs that cause the resistance due to the turbulent motion depends on the surface fall and they start from the lowest layers of the stream. As the depth of the stream is less near the sluice, the puffs have a greater retarding force than if the stream filled the normal wetted area of the canal, this excess of retarding power gradually decreases the velocity until it becomes the normal velocity of the canal.

In the case of the silt wedge formed at the head of a canal taking off from the river, without a sluice at the head, the water enters the canal at the river velocity, which is greater than the canal velocity, and the deposit of silt is due to the same cause as in the case where the water is controlled by a head sluice.

When the velocity of the water entering the canal decreases, the water will require a greater amount of the wetted area in which to flow, consequently, if silt has been deposited in the formerly unrequired portion of the wetted sectional area, the silt will become an obstruction to flow and will raise the surface or be washed away. It is known that a strong masonry work is required to raise the surface of the water permanently, as the raising of the surface causes scour, consequently the silt formerly deposited is gradually scoured out till the surface fall is the natural surface fall of the canal. This also shows that the silt cannot be deposited in the space occupied by the main current of water entering the canal, and gives a limit to the depth of silt that can be deposited in the shape of a wedge, as the silt even if deposited, could not remain there for any length of time unless the nature of the deposit was strong enough to resist the scour and raise the surface of the water permanently.

It follows from the above that if the total width of the vents of the sluice is less than the mean width of the canal, there is every probability of the deposit of silt remaining in a less extent after the flood in the river has subsided. This is often found to be the case in practice.

It also follows that when the canal takes off from a river without a weir in the river, even though there is no head sluice there will be a permanent wedge of silt, as the velocity of the water entering the canal must always be greater than the normal canal velocity. This is found to be the case in practice.

Before the water issuing from the sluice rises to the surface and flows in contact with the sides, there often occurs two whirlpools, one on each side of the main current. These whirlpools, which are commonly called "Backlash," occupy the space not required by the main stream issuing from the sluice, and are caused by the reduced pressure consequent on the high velocity of the water issuing from the sluice. The pressure of the water at the sides being the normal pressure, the water rushes from the sides along the face or wings of the sluice to satisfy the reduced pressure caused by the water issuing at a high velocity from the sluice, this produces a whirlpool as the pressure is constantly being reduced, and can never be satisfied as long as the velocity of the water issuing from the sluice is above a certain amount. The velocity of the water forming the whirlpool will depend on the pressure at the place where the water issues from the sluice, which pressure, according to Bernouilli's theorem, will decrease with the square of the velocity. The body of the water forming the whirlpool is entirely separate from the body of water issuing from the sluice, the same water flowing round and round.

I am, yours truly,

L. L. WICKHAM.

PUBLIC HEATING IN BERLIN.—A new scheme for supplying some public buildings of Berlin with heat, and also with warm water, was adopted in Berlin in July last. The warm water is to be derived from the exhaust steam of the turbo-dynamos of the Berlin electricity works and from some coke-heated boilers, and is to enter the pipes superheated at a temperature of 120 deg. C.; the pipes are to be laid in concrete conduits along the streets, the pipe sections to be welded together and to be provided with stuffing-boxes and with sliding bearings. The distribution area is to have a radius of 2·5 km., and to include some tenement houses. The contract has been given to the firm of Körting A.G., and it was hoped to start supply by next winter; the execution of the whole scheme appears doubtful, however, under actual conditions.

GERMAN ORES AND COAL OUTLOOK.—Speaking before the annual meeting of German metallurgists and miners, held at Berlin in July last, Dr. Krusch submitted estimates of the losses in coal and ores that the peace conditions will involve. His figures were expressed in per cents. of the actual German annual outputs, of stores left, and of ores still realisable, and are necessarily uncertain. As regards Upper Silesia, he estimated that Germany would lose 0·4 per cent. of the iron contained in the ores mined, and 3·7 per cent. of the iron stores; 76·3 per cent. of the zinc, and 54·4 per cent. of the lead in the ores would go, and 22·8 per cent. of the coal, and 40 per cent. of the coal stores. In Posen and Western Prussia there are only lignite deposits of local importance. The figures for the Saarbrücken district are: 6 per cent. of the coal output and 3 per cent. of the coal stores. Alsace-Lorraine is credited with 71·7 per cent. of the iron contents of the ore output, and with 77·4 per cent. of the realisable iron-ore; the outputs of potash and oil are estimated at 10 per cent. and 2 per cent. of the totals, the coal mined there at 3 per cent. of the output and 1 per cent. of the stores. The district Eupen-Malmedy would involve 1·6 per cent. of the zinc mined, and 0·4 per cent. of the lead. These last figures are surprisingly low.

CONCRETE AND FROST.

CONCRETE piers on the Canadian shores seem to suffer severely from the frost in tidal waters. The damage is apparently confined to the concrete surfaces which the tides expose to alternating freezing and thawing, processes which, one could easily imagine, would tend to disintegrate the concrete.

At Halifax in Nova Scotia, the air temperature may fall to −40 deg. F. in December when the sea water is still and above freezing point; in January and the following months the sea-water is itself down to freezing point, but in December particularly the temperature fluctuations would be detrimental to the concrete. To protect the concrete, Sir John Kennedy, consulting engineer to the Montreal Harbour Commissioners, proposed some years ago to face the concrete over the height of the tidal range with thick water-logged wooden planks, which would themselves undergo alternating freezing and thawing, whilst the concrete behind them would be protected. This practice we see—from a paper by Professor Louis V. King in the Transactions of the Royal Society of Canada, vol. 12, pages 115 to 119 (December, 1918, to March, 1919)—has proved quite successful. Unfortunately, King does not give technical particulars, nor any references to them, but confines himself to his studies of the "Penetration of Frost in Concrete Structure." He experimented with slabs of various pines, sometimes creosoted. He wetted the one surface of each of the two slabs of a pair and placed them face to face; exposing the pair to the cold, he obtained an "ice-sandwich," which he subsequently suspended in a warm room. Thus he ascertained that the frost hardly penetrates more than 4 cm. into such wood, and that hence an external heating of the concrete with planks 3 in. in thickness should be ample to protect the concrete in places which, with changing tides, would be exposed to air temperatures of −20 deg. C. and water temperatures of +5 deg. C. The water-logged pine had been lying in the sea-water for several years. It is quite possible that the freezing and thawing—the most powerful disintegration agent of mountains—has more to do with the destruction of some concrete structures than the action of the magnesium salts or the calcium sulphate of the sea-water, and the question is of particular interest also to concrete ships sailing in high latitudes. In the docks the change of the depth of immersion with loading and unloading would in a measure produce the effect that the tidal range has on stationary structures.

HYDRAULIC ROCK BLASTING.—A hydraulic device for the blasting of rock, and especially also for the demolition of concrete piers and foundations, is briefly described in the *Zeitschrift für Schiesswesen* of May 2 last. The device is due to Dr. Tübben, of the Armaturenfabrik Westfalia. A pressure pipe leads to a cylinder, 85 mm. diameter, in which eight pistons move, one after the other in telescope fashion. The cylinder is inserted into a hole drilled into the rock by an electric motor; the pistons are forced out and crack the rock. The drilling of the holes, about 1 in. in depth, is said to take 15 to 20 minutes, the blasting five minutes. When the rock has been cracked, a tap is opened and the water allowed to spurt back. The device is said to have proved very successful in mines and quarries, where the concussions of explosives would be dangerous.

ELECTROLYTIC PRODUCTION OF FLUORINE.—The Research Department of the Chemical Warfare Service of the United States studied, among other problems, the preparation of fluorine, and described in the *Journal of Physical Chemistry* of May last the process worked out by W. L. Argo, F. C. Mathers, B. Humiston and C. O. Anderson. The usual method is that of Moissan and Lebeau, electrolysis of anhydrous hydrofluoric acid HF, to which some potassium fluoride KF is added to make the liquid a conductor of electricity. The vessel should be of platinum; copper may be used, as was found later, but the electrodes must be of platinum or platinum-iridium. Acheson graphite is attacked; the cell must artificially be cooled. The hydrofluoric acid may be made in lead vessels, but it takes up lead then and is hence unsuitable for analytical purposes. The HF is sometimes prepared by heating the compound HF KF, which is more easy to deal with than the viscous acid. Argo and his collaborators electrolyse this fused compound instead of its solution in hydrofluoric acid. The HF KF fuses at about 200 deg. C. The fusion is accompanied by a slight decomposition, and as the salt is never quite free of water, the first gas evolved during the electrolysis is impure. The electrolysis is conducted in a heavy copper cylinder, about which is wound a nichrome coil. The copper is slightly attacked by the bath. The copper is the kathode; the anode is a rod of graphite, which is surrounded by a diaphragm, the space between the carbon and the diaphragm being packed with pure powdered fluorspar CaF_2. The KF becomes concentrated in the bath, and when the liquid has turned too viscous, in spite of the addition of more HF, the cell contents are poured out into a copper basin, in which the KF solidifies. The electrolysis evolves heat, and with too high current density there may be sparking and considerable heat evolution in the cell. In fact, the external heating seems unnecessary, and the process does not seem to give much satisfaction, since modifications are suggested. The use of NaF instead of KF seems advisable. But fluorine is, under ordinary conditions, probably the most active element known, as it inflames coal gas, charcoal and sulphur instantaneously and attacks almost any element. According to the new experiments, however, pure fluorine is not poisonous and not so irritating to the lungs as generally believed, is, in fact, less so than chlorine.

RAPID VERTICAL SAWING MACHINE.

CONSTRUCTED BY MESSRS. EDWARD G. HERBERT, LIMITED, ENGINEERS, MANCHESTER.

Fig. 1.

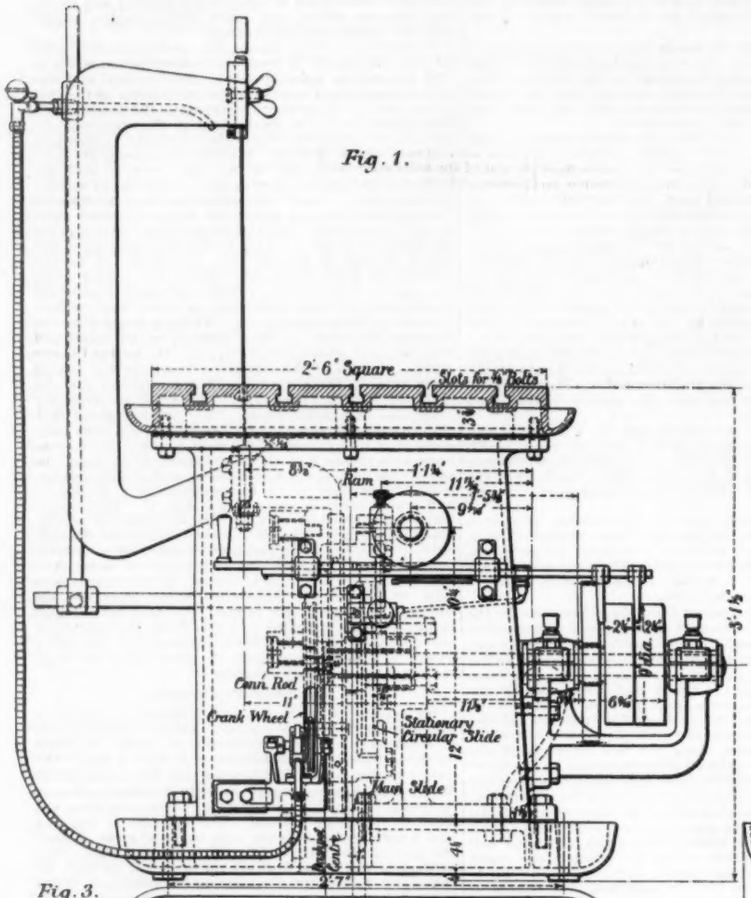


Fig. 2.

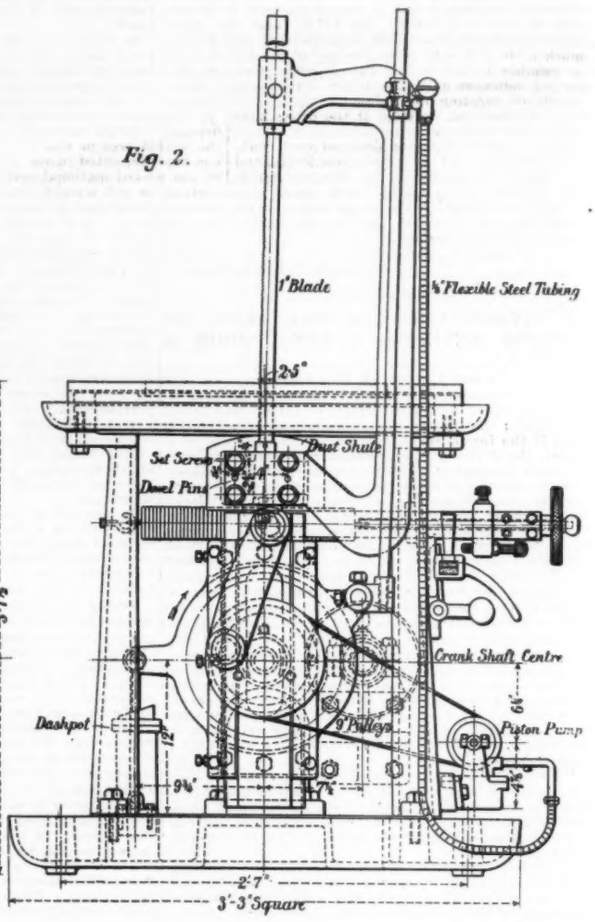
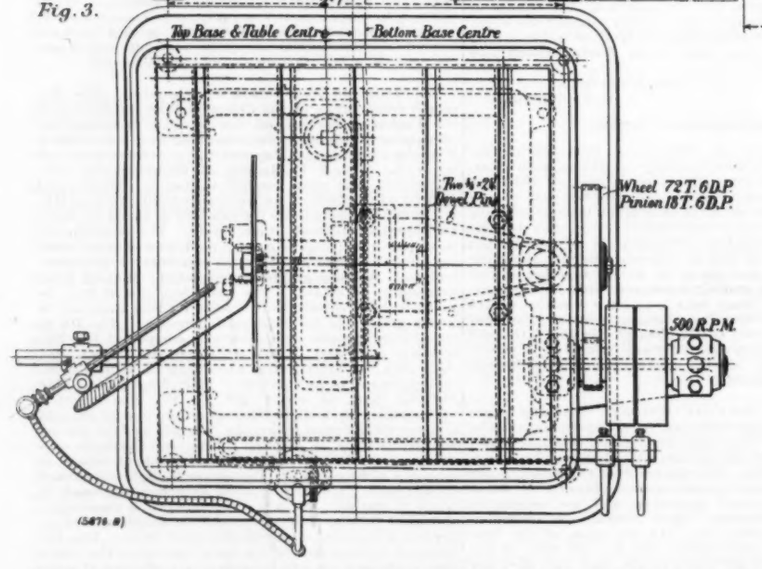


Fig. 3.



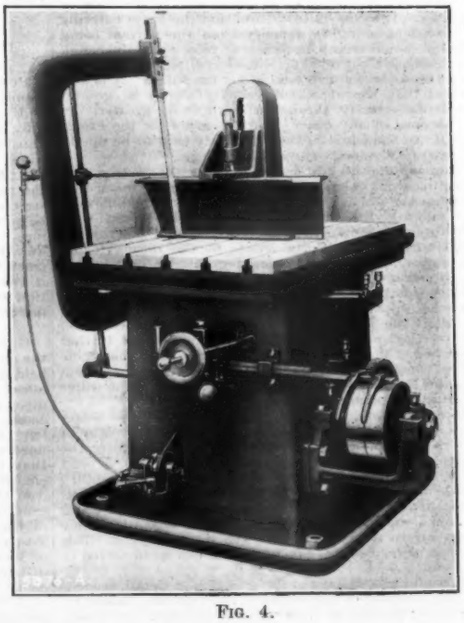


FIG. 4.

ON the present and opposite pages we illustrate a very useful form of hack-sawing machine, which has recently been designed and constructed by Messrs. Edward G. Herbert, Limited, of Atlas Works, Levenshulme, Manchester. The machine is capable of cutting through a bar, 9 in. in diameter, and of bevelling a 12-in. girder at any angle, but it is equally suitable for cutting out the forks of connecting-rod forgings, notching and trimming plates or rolled steel sections, and of carrying out a great variety of work usually done on a slotting machine or by other expensive methods.

Figs. 1, 2 and 3, on this page, are, respectively, front and side elevations, and a plan of the machine, the general appearance of which is shown by the photograph reproduced in Fig. 4. Some details of its construction are given in Figs. 5 to 8 on the opposite page. It will be seen that the machine comprises a pedestal casting on which is mounted a table provided with "tee" slots for holding down the work; the working surface of this table measures 30 ins. square. The saw blade works, with a more or less vertical motion, through a slot in this table, and, as is best shown in the plan, Fig. 3, the frame carrying the saw is set at an angle of 45 deg. with the direction of the feed motion of the saw. This feature is an important point in the design, as it enables the machine to operate on work of

RAPID VERTICAL SAWING MACHINE.

CONSTRUCTED BY MESSRS. EDWARD G. HERBERT, LIMITED, ENGINEERS, MANCHESTER.

Fig. 5.

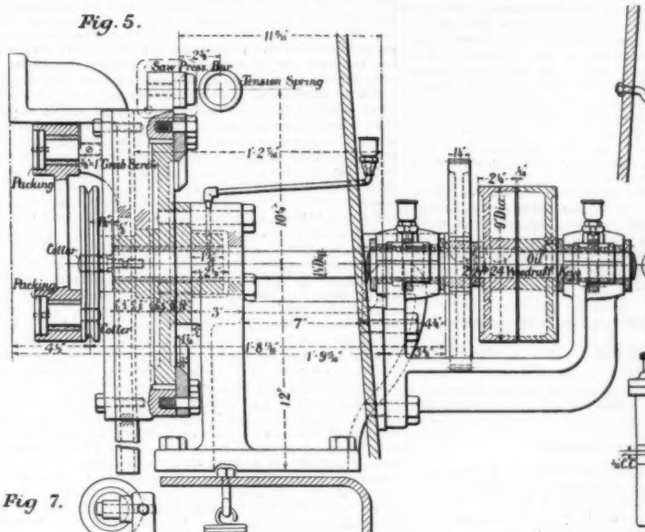


Fig. 6.

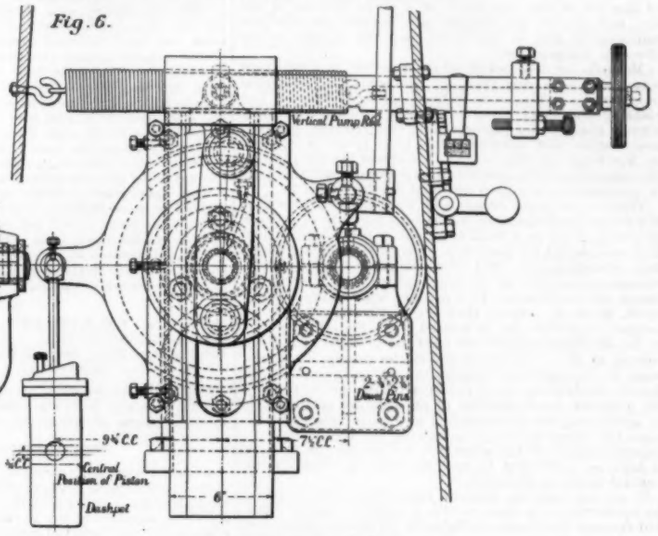


Fig 7.

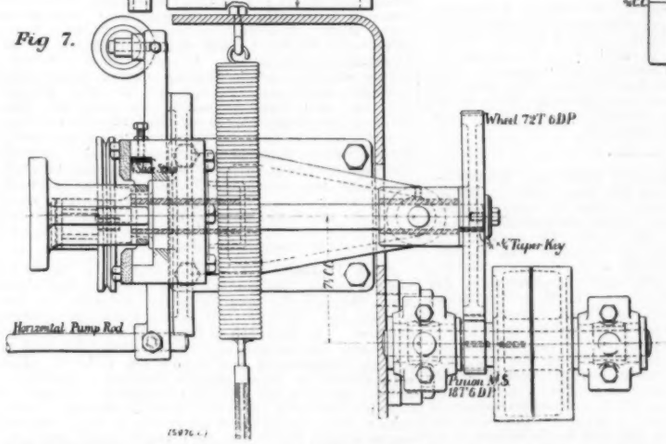
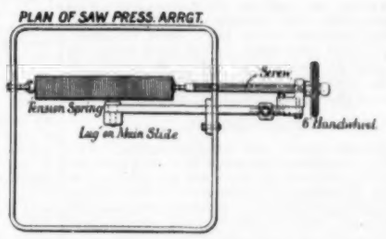


Fig. 8.



unlimited length when cutting either longitudinally or transversely.

The driving arrangements, which can be followed by careful inspection of Figs. 1, 2 and 3, are more clearly shown in Figs. 5, 6 and 7. As will be seen a pinion keyed on to the same shaft as the fast pulley, which runs at 500 r.p.m., drives a gear wheel with a 4 : 1 speed ratio keyed on to one end of a second shaft. At the other end of this shaft is a crank disc, which is coupled to an "L" shaped ram by a short connecting rod, and, by this means, the ram is caused to reciprocate at the rate of 125 double strokes per minute. This ram, to which the saw frame is bolted, works in a long slide formed in a swinging frame, which is pivoted on the outside of the crankshaft bearing and gibbed to a circular cast-iron plate bolted on to the bearing; a long slot is formed in the ram to clear the crankshaft which passes through it. An inspection of Figs. 5 and 6 will make the whole arrangement clear, and it will be evident that the ram and slide, together with the saw frame and blade, are free to turn about the axis of the crankshaft. A glance at Fig. 1 will also show another good feature of the design, viz., that the form of the ram is such that the suds and cuttings from the saw fall clear of the working parts.

The saw is fed into the work by means of the powerful helical spring shown in most of the drawings. One end of this spring is fixed to the pedestal casting, and the other end is attached to a long screw which works in a nut carried by a bracket bolted on to a flat bar. This bar, as is best shown in Fig. 8, is pivotally connected to the swinging frame, so that the spring tends to turn the frame in an anti-clockwise direction, as seen in Fig. 6, but the frame is prevented from moving too rapidly by means of an oil dashpot shown in the same illustration. The tension of the spring, and consequently the pressure of the saw blade on the work, can be adjusted by means of the screw and hand wheel shown. A total feed motion of 15 in. is obtainable by the spring mechanism, but longitudinal cuts of unlimited length can obviously be made by shifting the work from time to time. The oil dashpot, above referred to, has another important function besides that of regulating the rate of movement of the swinging frame. Reference to Fig. 2 will show that the saw blade is set at a small angle, usually 2½ deg. to 3 deg., with the direction of its reciprocating motion. The effect of this is that, during the upward, or cutting, stroke, the saw blade and frame are pressed backwards against the action of the feed spring. On the downward stroke the dashpot delays the return of the saw into contact with the work, and thus materially diminishes the wear of the blade. An arrangement of this nature is used on all Messrs. Herbert's rapid saws.

The method of stopping the machine automatically at the end of a cut can best be followed from an examination of Figs. 1 and 2. It will be seen, in Fig. 1, that the driving belt passes between two fingers mounted on a horizontal sliding bar, to which is attached a spring tending to move the bar to the right. To start the machine this bar is pulled to the left, against the action of the spring, bringing the belt on to the fast pulley, and the bar is held in this position by means of a weighted bell-crank lever, one arm of which engages with a notch in the side of the bar. At the completion of the cut an adjustable screw stop, carried by the flat bar referred to above in connection with the spring-feed mechanism, comes into contact with the bell-crank lever and knocks it out of engagement with the bar controlling the position of the belt. The spring is thus enabled to pull the bar, in Fig. 1, to the right and so shift the belt on to the loose pulley and stop the machine. Cutting lubricant is supplied by means of a pump of the piston type driven by a circular belt from the crank disc, as shown in Fig. 2. The pump delivery is connected by flexible steel tubing to a nozzle rigidly connected to the saw frame, so that, when once adjusted, the stream of lubricant follows the saw through the work without further attention.

The machine has been substantially designed and constructed throughout, and the makers claim that it is in every way fitted for continuous work at high speeds. Special attention has been given to the lubrication of the working parts and to keeping them clear of cutting lubricant and cuttings.

TIN: AN IDEAL PYROMETRIC SUBSTANCE.*

By E. F. NORTHRUP,† Trenton, N.J.

THESE brief notes respecting the properties of pure tin that make it useful as a pyrometric substance summarise information gathered by the writer in an extensive experimental investigation on the electrical properties of metals in the molten state.

Tin in quantities sufficient for pyrometric purposes may be obtained at relatively low cost and in a state of high purity. The metal melts at 232 deg. C. and, according to determinations made by Greenwood, 1909, does not begin to boil until a temperature of 2,270 deg. C. is reached. The writer can assert, from personal observations carefully made, that tin shows no tendency to boil at a temperature of 1,680 deg. C. If Greenwood's observations are correct, the temperature interval, 2,038 deg. C., in which tin exists as a liquid under atmospheric pressure, exceeds that of any other substance.

It has never been observed, as far as the writer is aware, that tin forms any chemical union, as carbide, with carbon at the highest temperatures at which it can exist as a liquid. It is quite certain from the writer's personal observation that tin heated in Acheson graphite to 1,680 deg. C. remains chemically uncontaminated.

Wires of pure tungsten do not dissolve in molten tin at temperatures at least as high as 1,680 deg. C. Tungsten wires or rods may, therefore, be used as electrodes dipping into molten tin when required for measuring the resistance of the molten metal at very high temperatures.

When tin is raised to a high temperature in a covered graphite container, the CO atmosphere that exists above its surface has a reducing action, which maintains this surface of mirror brightness. Incidentally, tin maintained molten in a crucible of Acheson graphite makes a most excellent bath into which may be inserted several pyrometers that are to be intercompared at the same temperature.

But the two properties of tin that, in its molten state, make it particularly valuable as a pyrometric substance, are the strictly linear character of the increase of a given volume in resistivity with increase in temperature and the decrease of a given volume in density with increase in temperature. The increase in the resistivity of tin in the molten state has been studied by the writer with very great care, and he can assert positively that up to a temperature at least as high as 1,680 deg. C., and very probably beyond this temperature, the resistivity of the metal increases linearly with increase in

* Paper to be submitted for discussion at the September meeting of the American Institute of Mining and Metallurgical Engineers.

† President, Pyrolectric Instrument Company.

the temperature. The same can be asserted in regard to the decrease in the density with increase in temperature.

When the coefficients have once been accurately determined then, assuming that suitable methods are available for accurately measuring either the resistivity of the tin or the expansion of a given volume of the tin, one can in the former case deduce the absolute temperature and in the latter case the change in the absolute temperature.

Methods for accomplishing these results in a practical way have been described by the writer in numerous publications. The most refined method and the one yielding the most accurate results in an exceedingly simple manner for determining the relation between temperature and resistivity has been given in a paper by Northrup and Sherwood.* A method for determining the expansion of tin or its decrease in density with increase in temperature has been outlined by the writer.†

There is no more reason why one should go back to the volume expansion or increase in pressure of a given quantity of gas as a final standard of temperature than that one should go back to a pure element like tin as a final standard, provided the properties of this latter substance are related to temperature in a manner as simple as the former. It is now, at least in the writer's mind, quite as certain that the resistivity of a given volume of molten tin is related by a straight-line law to the absolute temperature as is the pressure of a given volume of gas. Gas thermometry, for practical reasons, ends at the melting temperature of palladium, 1,550 deg. C., while there are no practical limitations to prevent the accurate determination of an absolute temperature by measuring the resistivity of a definite volume of tin when the temperature by measuring the resistivity of a definite volume of tin when the temperature is at least as high as 1,680 deg. C. and probably as high as the melting point of platinum.

If, at the time the writer's researches were made on the resistivity of molten metals, a high-frequency induction furnace had been available in its present perfected form for laboratory use, all his determinations could have been made with much greater ease and rapidity, and higher temperatures could have been obtained. It is earnestly hoped that some investigator with the simple means now at his disposal will make a redetermination of the melting points of the higher melting metals in terms of the known resistivity of pure tin.

Assistant Examiners in the Patent Office.—The Civil Service Commissioners announce that an examination will begin on October 28 next for the purpose of filling vacancies as Assistant Examiners in the Patent Office. The examination will be confined in the main to candidates who have served in His Majesty's Forces and will consist of a qualifying examination followed by interview by the Selection Board. The subjects of the qualifying examination are English composition, précis writing, general knowledge and *one* of the following: General chemistry, electricity and magnetism, mechanics and mechanism. The limits of age are 20–30. Initial salary 150*l.* a year, together with a war bonus. Copies of the regulations and forms of application may be obtained on application to the Secretary, Civil Service Commission, Burlington-gardens, London, W. 1. The last day for making application is September 18.

Trade at Japanese Ports.—According to an exhaustive compilation of trade statistics recently issued by the Yokohama Chamber of Commerce and referred to in *The London and China Telegraph*, America enjoyed 50 per cent. of the foreign trade going through the port of Yokohama in 1918, but less than 5 per cent. of the trade was carried in American bottoms. Only 2 per cent. of the commerce between Yokohama and American ports was carried in American ships. The total business between American ports and Yokohama was more than one-half billion yen in 1918, of which exports to America were twice the value of the imports. The same relative value between exports and imports is found in the trade of this port with Great Britain during 1918, while in the case of France the ratio is 100 to 1 in favour of the exports. The tonnage of American merchant vessels coming into Yokohama has dropped from 811,636 in 1913, to 175,952 in 1918. British tonnage dropped from 3,051,247 in 1913, to 315,821 in 1918.

Universal Directory of Railway Officials.—A copy of this directory for the current year, the 25th of publication, has recently come to hand. The book, which is compiled from official sources under the direction of Mr. S. R. Blundstone, gives a list of all railways and tramways worked by power in the United Kingdom, mentioning the length of line, and amount of rolling-stock, and giving the names of the chief officials in each case. Similar information is given for most of the foreign railways of the world, but it has not yet been possible to include particulars of lines in the countries or districts which have been subjected to military operations during the war. A very valuable feature of the work is the complete alphabetical list of railway officials, and this has been corrected with particular care and attention. The whole of the matter has, in fact, been revised and brought up to date, and a number of additions have been made. The book is published by the Directory Publishing Company, Limited, of 15, Farringdon-avenue, London, E.C. 4, and the subscription price is 15*s.*

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* "New Methods for Measuring Resistivity of Molten Materials: Results for Certain Alloys." Journal Frank. Inst. (Oct., 1916), 182, 477.

† "Production of High Temperature and Its Measurement." Trans. Faraday Soc. (1918), 13.

COPPER CONDUCTORS.

The British Engineering Standards Association have issued their report, No. 7 (revised, 1919), British Standard Specification for dimensions of insulated annealed copper conductors for electric power and light.

The wire gauge, as a means of designating the conductors, has been dispensed with, and the number of sizes has been reduced considerably. The report includes a table giving the values of the resistance of a conductor 1,000 yards long and 1 sq. in. in sectional area, at every degree between 40 Fahr. and 120 Fahr., together with the constants to be employed in converting the resistance of a wire from any temperature between these limits to 60 deg. Fahr. It also contains tables giving details of the conductors, the thicknesses of the dielectric lead sheathing, armouring, bedding, &c., with the values of the test pressures.

The specification deals with circular wires from 0·0076 in. to 0·1030 in. in diameter, solid and stranded conductors from 0·001 sq. in. to 1 sq. in., and with flexible conductors from 0·0006 sq. in. to 0·5 sq. in.

The thicknesses of the dielectric and lead sheathing, and the values of the test pressures, are given for the following classes of cable:—

Dielectric.	Working pressure.
Paper ...	660, 2,200, 3,300, 5,500, 6,600, 11,000 volts.
Jute ...	660 volts.
Rubber ...	250, 660, 2,200, 3,300, 5,500, 6,600, 11,000 volts.

Copies of the report at the price of 1*s.* 2*d.*, post free, can be obtained from the offices of the Association, 28, Victoria-street, Westminster, S.W.1.

Large Francis Turbines.—We read in *Engineering News Record*, New York, that Francis-type turbine rated at 22,500 h.p., and operating under a head of 800 ft., are to be installed at the Kern River No. 3 hydro-electric plant of the Southern California Edison Company. They are said to be the lightest-head turbines that have ever been built. The generators are of unusual design, in that they will furnish either 50-cycle or 60-cycle energy, two different systems being served.

The Institute of Metals: Sheffield Meeting.—An important addition has just been made to the list of papers that are to be presented at the annual autumn meeting of the Institute of Metals in Sheffield on Wednesday and Thursday, September 24 and 25. As originally published, the list included nine papers; there are now ten, the latest communication being a note by an American metallurgical engineer, Dr. Zay Jeffries of Cleveland, Ohio, on "The Micro-Mechanism of the Ageing of Duralumin," a subject of great practical interest to all concerned with the working or use of an aluminium alloy that has played a vastly important part in aeronautical engineering during the war. Dr. Jeffries has come over to this country in order to be able to present his communication in person to the Institute at its Sheffield meeting, at which a record attendance of home and overseas members is assured. Copies of the note are now in the press, and will be forwarded to all members and applicants for membership upon application being made to Mr. G. Shaw Scott, M.Sc., Secretary, Institute of Metals, 36, Victoria-street, S.W. 1, from whom also there can be obtained membership forms providing (in the event of success in the forthcoming ballot) for election in time for participation in the functions at Sheffield in cases where these forms are returned not later than noon on Wednesday next, September 10.

French Interest in Shipping Plans at Shanghai.—We read in *The London and China Telegraph* that the Nicholas Tsu Shipbuilding and Engineering Works at Shanghai were mortgaged to the Messageries Maritimes, and on the expiration of the mortgage the latter decided to take over the works. Owing to the objection of the Chinese Government to having a purely Chinese enterprise pass over to the French in its entirety, the French decided to sell the Chinese Government a half interest, which was effected in the form of a special arrangement with the Government, effective in May, 1919, the purchase price being Shanghai Tls. 500,000 (597,500 dols.). The works, covering an area of about eight acres of land, consisted originally of native docks where junks and lorchas were repaired in the early days of foreign occupation in the East. In 1896 Mr. Tsu opened up his engine works, constructing small gas engines used in the operation of rice mills all over China. Small parts for other engines were also made. Gradually the works expanded, and in time farm machinery, tramway and railway rolling-stock were also successfully manufactured. Later launches of all sizes were turned out. Since 1914, when the war caused most of the vessels trading with the East to be taken off, these works were enlarged and facilities installed for the construction of large steamers. At present four vessels of 5,000 tons each can be constructed at one time. Two vessels have recently been completed. A blast furnace has recently been installed and experiments made with iron ore taken from the ore fields between Nanking and Wuhu. A rolling mill is also in operation and the works are using plates of excellent quality which are turned out by this mill. In view of the fact that Mr. Tsu has large interests in the extensive ore fields above mentioned, the Nicholas Tsu yard will, when these ore fields are developed, be in a position to compete more favourably with the world's shipbuilding yards than has been possible up to the present time.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—To all outward appearances South Yorkshire's staple industries have completely recovered from the temporarily crippling effect of the county coal strike, and work in all branches is in full swing. Unemployment, which reached one of the highest levels recorded since before the war, is being reduced to normal proportions as the industries get into their stride and the workers are absorbed. Less than a fortnight ago over 20,000 workers were on the books of the Sheffield Labour Exchange drawing unemployment donation. That number has now been reduced to 8,000, showing that there was plenty of work awaiting completion when the necessary coal supply was available. From an industrial standpoint the biggest event of the week, affecting not only South Yorkshire, but Nottinghamshire and the Midlands, has been the practical completion of the scheme by which Messrs. Cammell Laird and Co., Limited, amalgamate with the Midland Carriage and Wagon Company, of Birmingham. This will give Messrs. Cammell an outlet for a large part of the Penistone steel output, where, owing to the large extensions made specially on war account, difficulty had been experienced in finding work for all the new furnaces. The amalgamation will also help materially at Nottingham, where Messrs. Cammell are taking over the National factory which they ran for the Government during the war, and where they propose to make steel railway wagons and carriages. The company have contracts in hand running over a long period. The raw material market has undergone little change. Supplies of basic material are still in urgent demand, and outside sources of production are being drawn upon to meet the call for semi-finished material. West Coast hematites are quoted at 11*l.*; East Coast hematites, 10*l.* 6*s.* 9*d.*; common bars, 22*l.* 10*s.*; hoops, 26*l.*; Lincolnshire basic, 9*l.* 5*s.*; Lincolnshire forge, 8*l.* 12*s.* 6*d.*; Derbyshire basic, 9*l.* 10*s.*; Derbyshire foundry, 9*l.* 3*s.* 6*d.*; Derbyshire forge, 8*l.* 10*s.* Movement in steel billets is steady despite underselling by cheaper competitors. Bessemer acids are quoted at 19*l.* 2*s.* 6*d.*; Siemens, 19*l.* 12*s.* 6*d.*; hard basic, 16*l.* 10*s.*, and soft basic, 15*l.* 5*s.* The engineering branches are steadily employed, but there is a marked slackness in crucible steel and in special steels. Exports of the latter tend to increase, but the quantity going for shipment compares unfavourably with pre-war trade. There is also an indication of an easing-off in some of the lighter branches, which, taken on the whole, have had a record year. Makers of twist drills and jack saw blades are getting towards the end of their largest bookings.

South Yorkshire Coal Trade.—Output at the pits is not yet normal, but is much more nearly so than a week ago. Supplies for manufacturing purposes on local account and for dispatch to inland works are in urgent demand. The approach of winter is causing house coal merchants considerable anxiety, as winter stocking has scarcely commenced and depôts are much in arrear with deliveries. Open market business is greatly restricted owing to the urgency of contract commitments. Coke is scarce with prices firm at the maximum. Quotations:—Best branch handpicked, 33*s.* to 34*s.*; Barnsley best silkstone, 33*s.* to 33*s.* 6*d.*; Derbyshire best brights, 31*s.* to 32*s.*; Derbyshire house coal, 28*s.* 6*d.* to 29*s.*; Derbyshire best large nuts, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire small nuts, 27*s.* 6*d.* to 28*s.* 6*d.*; Yorkshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; best slacks, 24*s.* to 25*s.* 6*d.*; nutty, 23*s.* to 24*s.*; smalls, 19*s.* to 20*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—Inquiry for Cleveland foundry pig is slightly quieter, but supply still falls a good deal short of requirements. Home consumers are rather heavily bought, but distribution continues to be hampered by truck shortage. Demand on Continental account is unabated, and, with prospects of more iron available for shipment and likelihood of licences being issued more freely—though up to the present they are granted sparingly—expansion of export trade is anticipated. Forge iron is very plentiful and likely to become even more abundant as furnaces are not working very satisfactorily, with the result that they are turning out more of the inferior qualities than the better kinds of iron. For home consumption No. 3 G.M.B. and No. 4 foundry stand at 160*s.*; No. 1 is 164*s.*; and No. 4 forge is 157*s.*; and for export prices are 5*s.* above the foregoing quotations.

Hematite Iron.—The situation as regards East Coast hematite is easier, supplies being more plentiful, due to many home needs having been met and to foreign demand being only quiet. Rates of exchange are an obstacle to export trade, and some countries are fairly well bought at below current rates. Makers have good order books, but they are quite open to entertain forward business. Nos. 1, 2 and 3 are 200*s.* for home use and 205*s.* for despatch to foreign destinations, and No. 1 is 202*s.* 6*d.* for home purposes and 207*s.* 6*d.* for export.

Foreign Ore.—The foreign ore trade is idle. Consumers have rather large stocks and are regularly receiving substantial supplies in fulfilment of running contracts, so that they are not in the market to buy. Rubio of 50 per cent. quality is 53*s.* 6*d.* c.i.f. Tees, and the freight Bilbao-Middlesbrough is 25*s.*

Coke.—Coke is scarce, though the shortage is hardly so acute as it has been. Medium blast furnace kind is

48*s.* at the ovens and low-phosphorus sort 49*s.* 6*d.* at the ovens.

Manufactured Iron and Steel.—Producers of manufactured iron and steel are busily employed, and in some branches demand is better. Substantial orders for sheets are reported to have been booked at advanced rates. Export prices are not fixed, but are rather above the following, which rule for home trade:—Common iron bars, 22*l.*; marked bars, 24*l.* 10*s.*; strip iron, 22*l.* 5*s.*; black sheets, 24 gauge, 24*l.*; galvanised sheets, 24 gauge, 29*l.* 10*s.* to 30*l.*; steel ship, bridge and tank plates, 18*l.* 5*s.*; steel angles, 17*l.* 15*s.*; steel joist, 17*l.* 10*s.*; steel hoops, 23*l.*, and heavy sections of steel rails 16*l.* 10*s.*

Shipments of Iron and Steel.—August shipments of iron and steel from the port of Middlesbrough totalled 43,374 tons as compared with total clearances of 36,571 tons for the previous month. Pig iron shipped last month amounted to 23,856 tons, manufactured iron 60,590 tons, and steel to 18,928 tons, as against July loadings of 15,410 tons of pig iron, 1,028 tons of manufactured iron, and 20,133 tons of steel. Only 1,785 tons of the pig iron shipped last month went to coastwise customers, whilst 22,071 tons went to Colonial and foreign destinations. The principal customers were:—Belgium, 10,793 tons; Italy, 3,430 tons; Japan, 2,600 tons; France, 2,070 tons, and Denmark 1,225 tons. Of the manufactured iron cleared in August only 25 tons went coastwise, 565 tons going abroad. India was the largest buyer, taking 333 tons. Foreign purchasers last month received 15,555 tons of steel and coastwise customers 3,373 tons, the chief importers being:—India, 6,369 tons; Denmark, 1,550 tons; Spain, 1,394 tons, and Japan, 1,156 tons.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—Active conditions continue to rule in the Scotch steel trade, and there is no slackening off in the demand for supplies for current use. For all classes of material commitments are largely of the near date delivery character, and even sellers show little disposition to contract much ahead. Makers of sectional material have only a fair amount of work on hand, and the demand for supplies is not pressing. Quite a satisfactory business is being done in black sheets, and makers are comfortably placed for the present, while for galvanised sheets the outlook is not too encouraging. In the steel trade generally the bulk of the business is still on home account, and no great tonnage is available for export. Prices are without change, and almost all classes of buyers having seemingly become accustomed to the present high level of values, are more freely placing their orders, with the result that the present activity is likely to continue. The competition from abroad is not being feared so much at the moment, and owing to the difficulties of delivery, especially in the case of steel material from America, buyers in general have little inclination to place contracts there.

Malleable Iron Trade.—In the West of Scotland malleable iron works very satisfactory conditions are general, and there is a good amount of work on hand, mainly on home account. Fresh bookings have been of a fairly healthy nature during the past week, and the immediate outlook is good, with steady running of the mills ensured for some time. With the home demand keeping up so well, there is little material going through for shipment. Prices remain firm, and no change has been made in "Crown" bars, which are called 21*l.* 12*s.* 6*d.* per ton, net, Glasgow.

Scotch Pig-iron Trade.—The position of affairs in the Scotch pig-iron trade has varied very little over the week except that there are indications of a slightly better tonnage. Of both foundry and forge iron there is rather more available, but the tightness of hematite continues, as consumption is on a large scale. Prices are unaltered, and keep very firm.

New Clyde Shipyard.—A new private limited liability company has just been formed and arrangements made for the laying-out of another shipyard on the Clyde. The position taken over is at Scotstoun, and the river frontage will be about 650 ft., giving accommodation for five vessels of from 10,000 tons to 12,000 tons. The managing director of the new concern is Mr. Hugh M. Macmillan, late shipyard director at the Fairfield shipbuilding yard, Govan, and formerly of Belfast, while his immediate associate will be Mr. Donald Bremner, late head of Messrs. Dunlop, Bremner and Co., Limited, Port Glasgow.

Shipbuilding.—Much activity has been general in the Scotch shipbuilding yards during the past month, and the outcome was very satisfactory. The launches for the different districts are as follow:—

	Vessels.	Tons.
The Clyde	29	52,181
The Tay	1	2,000
The Dee	2	1,205
Total	32	55,386

The Clyde total for the month of August was a very good average for the year, and has only been exceeded twice this year, in April when the total was 85,774 tons, and in June when the figure was 83,907 tons. In comparison with pre-war years it is interesting to note that only on four previous occasions has the total output for August been larger. From the returns it would seem that the Clyde shows signs of returning very quickly to its proud position as a shipbuilding centre because the output for the eight months to date now stands at 184 vessels totalling 347,579 tons. Certainly the total has been exceeded on several occasions before the war, but when the state of the labour market is considered, and the fact that many yards have been changing from Admiralty to mercantile work the tonnage launched for the year to date is very encouraging. The year's figures for the various districts are as follow:—

	Vessels.	Tons.
The Clyde	184	347,579
The Forth	20	30,251
The Tay	10	13,368
The Dee	35	7,131
Total	249	398,329

Amongst the larger vessels launched last month were the light cruiser Raleigh of 10,000 tons, by Messrs. Wm. Beardmore and Co., Limited, for the Admiralty; the turbine screw steamer, Nardana, 8,000 tons, by Messrs. Barclay, Curle and Co., Limited, for the British India Steam Navigation Company, Limited, London; and the cargo steamer, War Gaekwar, 8,000 tons, by Messrs. Lithgows, Limited, Port Glasgow, for the Shipping Controller.

Further Clyde Interest of Belfast Firm.—It is now officially known that the firm of Messrs. Harland and Wolff, Limited, Belfast, has acquired still further interests on the Clyde, thus considerably extending its influence in Clyde shipbuilding. The two very old firms in which Messrs. Harland and Wolff will now be concerned are Messrs. D. and W. Henderson and Co., Limited, Partick, and Messrs. A. and J. Inglis, Limited, Pointhouse.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—Owing to an improvement in outputs and the resumption of work in the Yorkshire coalfield there has been more coal available of late, and prices show an easier tendency. Actual business is still difficult owing to the meagreness with which releases are granted, and lack of tipping accommodation. Shipping is plentiful, though not arriving so freely as of late, there are still a large number of vessels waiting cargoes. There is little alteration in prices for the better quality large coals as collieries generally are comfortably placed and have heavy arrears to work off. The top for Admiralty and Monmouthshire large coals is 85*s.*, and good drys are obtainable at 80*s.*, which is a reduction of 2*s.* 6*d.* to 5*s.* on the prices required a week ago. Smalls are also more plentiful, and the best steams range from 62*s.* 6*d.* to 67*s.* 6*d.*, though some sellers are quoting 70*s.* Cargo smalls range from 55*s.* to 60*s.*, and inferiors from 45*s.* In the bituminous section No. 2 throughs are worth no more than 65*s.* Coke is very scarce and firm at 105*s.*, and patent fuel is practically unobtainable, and nominal at 85*s.* Pitwood is plentiful, and as collieries are well stocked, the inquiry is poor. The local Allocation Committee has ceased to allocate, and merchants are now free to sell direct. Several parcels have changed hands at 60*s.*, which is 5*s.* below the maximum schedule, as exporters have been compelled to clear cargoes already in dock.

Newport.—Monmouthshire large coals, though more plentiful, have not altered much as regards prices, as collieries generally are fully booked over the next fortnight, and comfortably placed as regards tonnage, and are not prepared, except in isolated cases, to modify their ideas of prices. Black vein and Western Valley large still command up to 85*s.*, and Eastern Valleys from 80*s.* Smalls are on the easy side round 60*s.*

Coal Outputs.—In the week ending August 23 outputs in the Monmouthshire and South Wales coalfields amounted to 975,558 tons, compared with 904,464 tons in the preceding week. The output in the week ending August 23 is just over 6 per cent. less than in the best week in the previous twelve months, and 11 per cent. below the average weekly output in 1913.

Inland Coal Transport.—The announcement of the Board of Trade suspending the Coal Transport Reorganisation Scheme has been received with satisfaction as it is believed that any relaxation of official restrictions will benefit trade generally. Consumers are now at liberty to purchase from any colliery or merchant direct, though collieries are advised that supplies of coal must be maintained to the same purchasers as at present, subject to adjustments of supplies to merchants as may result from the change in customers.

Bunker Coals for Coasting Steamers.—It will be recalled that the South Wales coalowners had agreed to supply vessels in the British coasting trade with bunker coals at fixed prices. It is now reported that the Board of Trade intend to issue a schedule of fixed prices for bunkers for these steamers, and the South Wales coalowners have, therefore, abandoned their scheme.

BOOK REVIEWS IN AMERICAN JOURNALS.—The Post Office Department of the United States, says *Engineering News Record*, New York, holds that under the Zone Postage Act of October 3, 1917, a book review in any journal must be classed as advertising matter and must be subject to extra postage if the price of the book is given. Our American contemporary adds it would gladly pay the extra postage if that would end the matter, but under the law and ruling it would be compelled to stamp each book review "Advertisement," which would be as untrue as "confessions" obtained under duress.

NOTICE OF MEETING.

THE INSTITUTION OF MINING ENGINEERS.—The Thirtieth Annual General Meeting will be held at Birmingham, on Wednesday, September 10, 1919, at 11 a.m., in the Medical Theatre of the University of Birmingham, Edmund-street, Birmingham. The members will be welcomed to the city by Sir Oliver Lodge, D.Sc., LL.D., F.R.S., Principal of the University of Birmingham, and by the President (Mr. William Charlton) of the South Staffordshire and Warwickshire Institute of Mining Engineers. The members will dine together on Wednesday, September 10, at the Grand Hotel, Birmingham. A reception of the members by the Lord Mayor of Birmingham (Sir David Brooks, G.B.E.) and Lady Brooks will be held at the Council House, Birmingham, on the evening of Thursday, September 11. Arrangements have been made for visits to places of interest and works on September 11 and 12. The following papers will be read, or taken as read: (1) "Report of the Committee on 'The Control of Atmospheric Conditions in Hot and Deep Mines'"; (2) "Training of Officers and Men of the Tunnelling Companies of the Royal Engineers in Mine-rescue Work on Active Service in France," by G. F. F. Eagar; (3) "A New Method of Working Thick Seams of Coal at Baggeridge Colliery," by Dudley S. Newey, B.Sc., F.G.S.; (4) "Protractors," by T. G. Bocking; (5) "Magnetic Meridian Observations: a Method of Utilising the Kew Observatory Records," by T. G. Bocking. The following papers will be open for discussion: (*a*) "The Difficulties and Dangers of Mine-rescue Work on the Western Front; and Mining Operations carried out by Men Wearing Rescue-apparatus," by Lieut.-Colonel D. Dale Logan, D.S.O., M.D., D.P.H., *Trans. Inst M.E.*, vol. lvii, page 197; (*b*) "Accidents due to structural Defects of Apparatus or Injury to Apparatus; and the Future of the Proto Apparatus," by Lieut.-Colonel D. Dale Logan, D.S.O., M.D., D.P.H., *Trans. Inst. M.E.*, vol. lvii, page 223; (*c*) "The Examination of Coal in Relation to Coal-washing," by M. Wynter Blyth, B.A. (Cantab.), F.I.C., and L. T. O'Shea, M.Sc., F.I.C.; (*d*) "The Education of Colliery Managers for Administrative and Social Responsibilities," by William Maurice.

BETHLEHEM IRON ORE DOCK IN CHILE.—The iron ore dock of the Bethlehem-Chile Iron Mines, at Cruz Grande, Chile, construction of which was held up by the war, has just been completed, says *The Iron Trade Review*, Cleveland, Ohio. The dock has a capacity for 30,000 tons of ore, and is provided with 17 spouts by which all 17 hatches of the standard 20,000-ton ore boats of the company may be fed simultaneously. The dock is similar to the ore docks in Lake Superior. It is nearly 500 ft. long, and is loaded by discharging the ore from hopper cars at the top of the dock.

PAINT STANDARDS.—We read in *Railway Mechanical Engineer*, New York, that the Bureau of Standards of the United States Department of Commerce is engaged in a study of paint and paint materials, in consultation with a committee of scientific representatives of the Government Departments, including the Railroad Administration, with a view to making acceptable standard specifications to be promulgated by the Bureau for the information of the public. These, when issued, it is stated, will render available to the railroads a fund of information regarding paint which they have not had heretofore.

GERMAN ALUMINIUM WORKS AND STATE SUPPLY OF ELECTRICITY.—The war development of the aluminium industry was brisk in most countries, but particularly so in Germany. In a paper of the title of this paragraph, published by Richard Tröger in the *Zeitschrift des Vereines deutscher Ingenieure* of August 2 last, Tröger estimates the production of aluminium, before and at the end of the war, in units of 1,000 tons, as follows:—Germany, 1, 40; Austria, 11, 25; England, 7·5, 12; France, 18, 20; Italy, 1, 7; Norway, 1·5, 16; United States and Canada, 28, 73. Thus the number of new plants in Germany was very great, and their erection was, of course, very much more expensive than the construction of the pre-war plant had been. The installation of new German aluminium works was decided upon in 1915, and Tröger at that time was asked to report upon the problem. In 1916 three large new works were started, the Erftwerk, the Vereinigte Aluminiumwerk A.G., and the Innwerk (Bavaria). These aluminium works required 1,200,000,000 kw.-hours per year—that is, 43 per cent. of the whole electric energy available in Germany in 1913. The new power installed for the works was 200,000 kw. To meet the heavy power demands several of the largest electricity supply plants were coupled up. Thus the Erftwerk was connected by 100 km. of new power transmission line with the Rhenish-Westphalian Electricity Works and the lignite collieries of the district, and similar connections were established in other districts, notably at Bitterfeld and Golpa, and at Rummelsburg, near Berlin. Yet the charges on the capital invested and the general industrial outlook are so heavy and serious that Tröger considers that the State, already largely interested in the capital of the plants, will have to nationalise the electricity supply. He would connect all the large electricity supply stations, which now feed aluminium works, and oblige the neighbouring districts to take their electricity from these united stations. The problems also affect other metals and especially copper, since the price of aluminium is largely dependent upon the copper market.

HELL GATE BRIDGE, NEW YORK.

MR. GUSTAV LINDENTHALL, CHIEF ENGINEER.

(*For Description see Page* 295.)

FIG. 35. ASSEMBLING ARCH TRUSS IN BRIDGE SHOP YARD.

FIG. 36. SECTION OF ARCH TRUSS ASSEMBLED IN BRIDGE SHOP YARD.

HELL GATE BRIDGE,

MR. GUSTAV LINDENTHAL, CHIEF

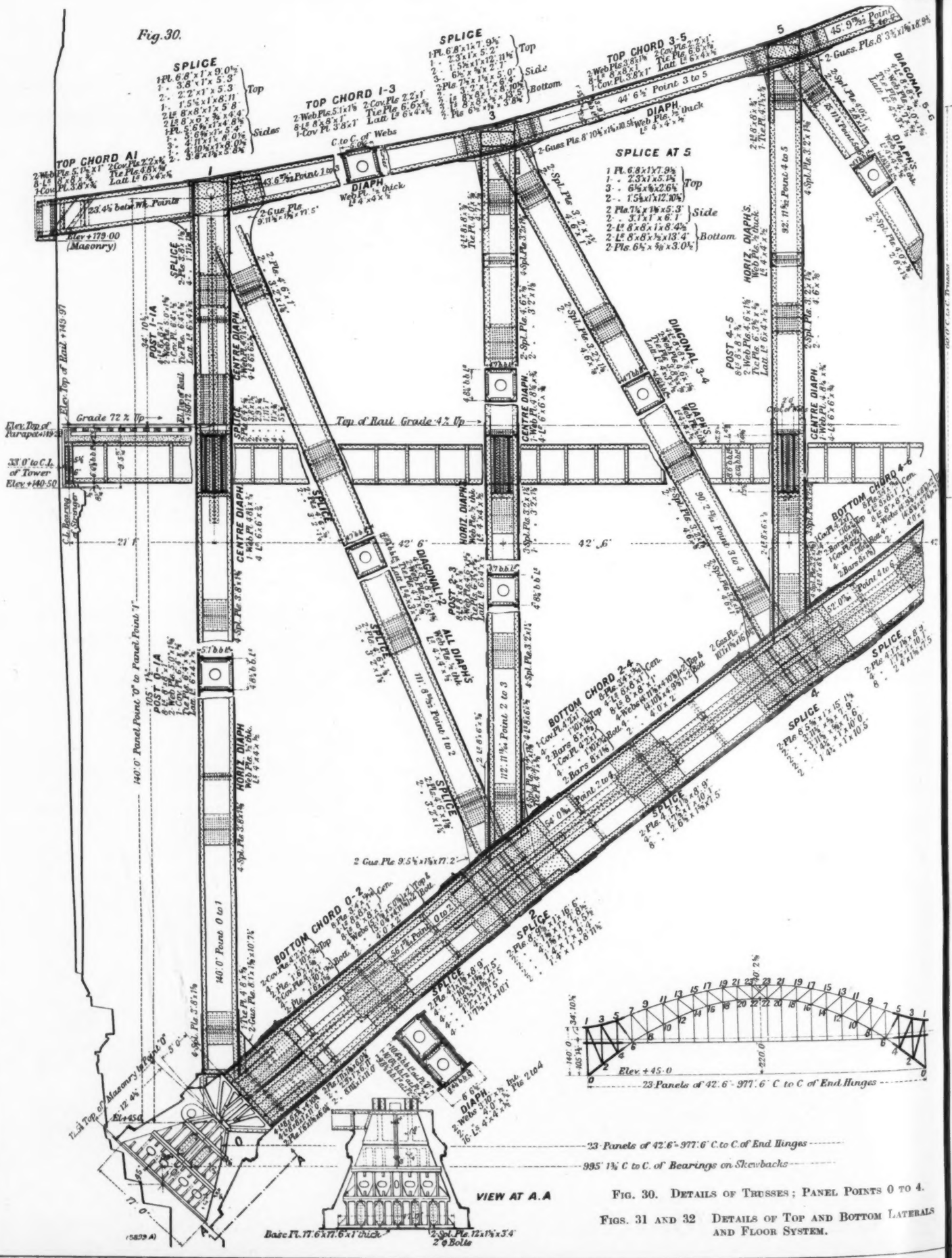

FIG. 30. DETAILS OF TRUSSES; PANEL POINTS 0 TO 4.

FIGS. 31 AND 32 DETAILS OF TOP AND BOTTOM LATERALS AND FLOOR SYSTEM.

BRIDGE, NEW YORK.

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(For Description see Page 295.)

Fig. 31.

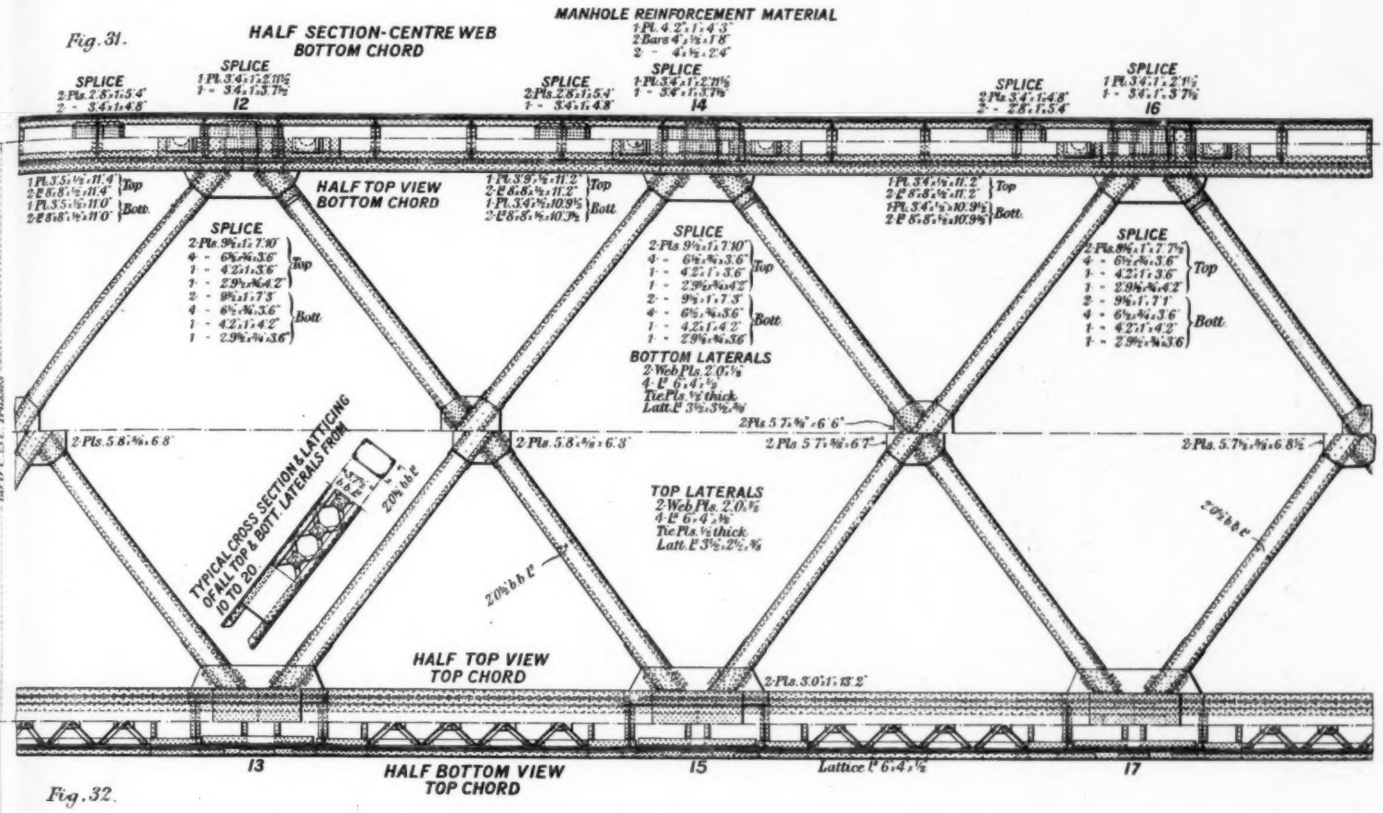
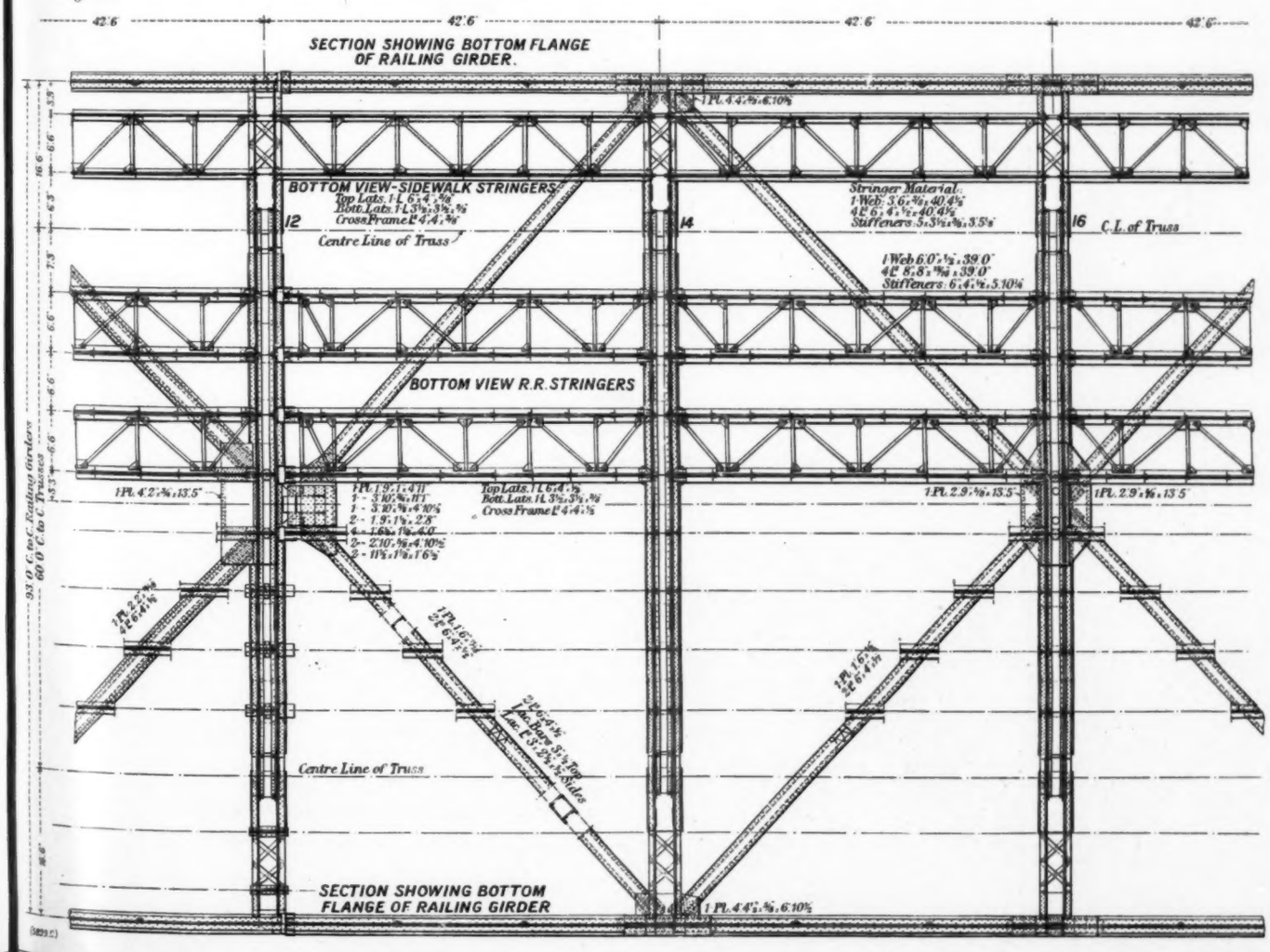

HALF SECTION-CENTRE WEB BOTTOM CHORD
MANHOLE REINFORCEMENT MATERIAL
1-Pl. 4'-2" x 1'-4 3/8"
2-Bars 4" x 1/2" x 1'-8"
2 - 4" x 1/2" x 2'-4"
SPLICE
2-Pls. 2'-8" x 1'-5 1/4"
2 - 3 1/2" x 1'-4 1/8"
1-Pl. 3'-4" x 1'-2 11/16"
1 - 3 1/2" x 1'-3 7/8"
SPLICE
2-Pls. 3'-4" x 1'-4 1/8"
2 - 2 1/2" x 1'-5 1/4"
1-Pl. 3'-4" x 1'-2 11/16"
1 - 3 1/2" x 1'-3 7/8"
12
14
16
HALF TOP VIEW BOTTOM CHORD
SPLICE
2-Pls. 9 1/2" x 1'-7 1/8"
4 - 6" x 7/8" x 3'-6"
1 - 4" x 2 1/2" x 3'-6"
1 - 2 9/16" x 1/2" x 4'-2"
2 - 9 1/2" x 1" x 7'-3"
4 - 6" x 7/8" x 3'-6"
1 - 4" x 2 1/2" x 4'-2"
1 - 2 9/16" x 7/8" x 3'-6"
Top
Bott
BOTTOM LATERALS
2-Web Pls. 2'-0" x 1/2"
4-L 6" x 4" x 1/2"
Tie Pls. 1/2" thick
Latt. L 3" x 2 1/2" x 1/4"
TOP LATERALS
2-Web Pls. 2'-0" x 1/2"
4-L 6" x 4" x 1/2"
Tie Pls. 1/2" thick
Latt. L 3" x 2 1/2" x 1/4"
TYPICAL CROSS SECTION & LATTICING OF ALL TOP & BOTT. LATERALS FROM 10 TO 20
20 bb c
HALF TOP VIEW TOP CHORD
HALF BOTTOM VIEW TOP CHORD
13
15
17
Lattice L 6" x 4" x 1/2"

Fig. 32.


42'-6"
SECTION SHOWING BOTTOM FLANGE OF RAILING GIRDER.
BOTTOM VIEW-SIDEWALK STRINGERS
Top Lats. 1 L 6" x 4" x 7/16"
Bott. Lats. 1 L 3 1/2" x 3 1/2" x 7/16"
Cross Frame L 4" x 4" x 7/16"
Centre Line of Truss
Stringer Material:
1-Web 3'-6" x 7/16" x 40'-4 1/2"
4 L 6" x 4" x 1/2" x 40'-4 1/2"
Stiffeners 5" x 3 1/2" x 7/16" x 3'-5"
1-Web 6'-0" x 1/2" x 39'-0"
4 L 6" x 3 1/2" x 1/2" x 39'-0"
Stiffeners 6" x 4" x 1/2" x 5'-10 1/2"
C.L. of Truss
BOTTOM VIEW R.R. STRINGERS
1-Pl. 4'-2" x 7/8" x 13'-5"
1-Pl. 2'-9" x 1/2" x 13'-5"
1-Pl. 2'-9" x 7/8" x 13'-5"
Top Lats. 1 L 6" x 4" x 1/2"
Bott. Lats. 1 L 3 1/2" x 3 1/2" x 7/16"
Cross Frame L 4" x 4" x 1/2"
Centre Line of Truss
SECTION SHOWING BOTTOM FLANGE OF RAILING GIRDER
1-Pl. 4'-4" x 7/8" x 6'-10 1/2"

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication, and certainly not later than Monday morning.

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NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of Supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 311.

ENGINEERING.

FRIDAY, SEPTEMBER 5, 1919.

THE INTERNAL-COMBUSTION TURBINE.

THE average multi-cylinder internal-combustion reciprocating engine can only be regarded as a somewhat complicated power unit. Its massive framing, large reciprocating weights and spring-closed valves compare unfavourably with the silent and compact modern high-speed turbine. The rotary motion of the turbine has made possible units of a power many multiples of the highest that can be obtained with the reciprocator. The internal-combustion turbine is a natural development in prime movers to which, judging from the records of patents granted, a large number of workers are still devoting their energies.

A review of past performance in this field and a discussion of future possibilities with such a machine are given in a paper, "Working Processes of Future Internal-Combustion Engines," by C. A. Norman, before the American Society of Automobile Engineers. The suitable thermo-dynamic cycle of operation can be conveniently subdivided into the two principle functions of compression and expansion. With the reciprocating engine, these are carried out in the one machine, exactly the same mechanism serving, and operating, furthermore, at a relatively high efficiency. With an internal-combustion turbine, compression must be carried out separately, and, for guidance, consideration may be given to the Brayton engine with its two cylinders, the one for compressing the working fluid driven from the other—the main cylinder in which ignition and expansion took place. This engine converted into power only 6 per cent. of the heat or work capacity of the fuel, but, nevertheless, was built in considerable numbers in the United States of America. The maximum obtainable efficiency with such a prime mover may be considered. In order that compression engines may deliver a margin of power the temperature range of expansion must be a multiple of that of compression. Assuming a final compression pressure of 150 lb. per square inch (a compression ratio of 1 to 10), the temperature range of compression is from 70 deg. to 560 deg. F. (or 1020 deg. absolute). The maximum absolute temperature that can be dealt with utilising the usual materials of construction is 4,000 deg. F. (or 4460 deg. F. absolute).

In this case the initial temperature of expansion is about four times the final temperature of compression, giving, theoretically, a ratio of net work to total expansion work of 75 per cent. Since, approximately, half the heat of the fuel remains in the gases at the end of expansion, the net energy utilisation is $0{\cdot}50 \times 0{\cdot}75 = 37{\cdot}5$ per cent. To what extent can an explosion turbine compare with these figues? Taking, for instance, the regenerative type of plant. A compressor passes compressed air through an exhaust air heater into the combustion chamber, in which the injected fuel is ignited and expanded through nozzles, and the resulting gases impinge on to a turbine wheel which absorbs their kinetic energy, and, finally, exhausts through the exhaust air heater aforementioned. The percentage of the expansion work available as net work with a ratio of absolute initial expansion temperature to compression end temperature of 4 is 75 per cent. This figure is very attractive, and if the transfer of heat from the exhaust gases to the air can be efficiently carried out, a reasonable fraction of this 75 per cent. of net work which is available, might be hoped for. These possibilities have led many experimenters into this field. The difficulties are severe. Reductions of efficiency either in the compression or the expansion elements, have a large effect in reducing the overall efficiency. If, for instance, the efficiency of the compressor is 60 per cent., and the efficiency of the expansion element is also 60 per cent., the 75 per cent. of net work is not merely reduced to 75 per cent. $\times$ ·60, but is reduced to 18 per cent. That is, only 18 per cent. of the expansion work is available as net work, and if 50 per cent. be the figure for the efficiency of both the compression and expansion, no work at all will be given out by the machine, all the available energy developed being required merely to drive the compressor.

Can sufficiently high efficiencies be obtained with the turbine plant to compare at all favourably with the 37 per cent. or so overall figure obtained with reciprocating units, quite apart from the practical question of suitable materials to withstand the severe temperature conditions? The design must strictly avoid, so far as is possible, friction, throttling and cooling losses. With turbines in the past, the rotation or windage losses in the turbine part and other turbulence losses in the centrifugal compressor have proved most serious obstacles.

It should be pointed out, however, that one substantial difference exists between the usual piston internal-combustion engine and the separate compression and expansion system necessary to the turbine. With the usual working cycle the expansion ratio cannot be greater than the compression ratio, so that expansion cannot be carried down to atmospheric pressure. For this reason, the lower the mean effective pressure the higher the theoretical efficiency, and with Diesel engines it has often been recorded that the highest overall efficiency, even taking friction losses, &c., into account, occurs at less than full load. With separate compression and expansion units this law does not hold, and the expansion ratio can be greater than the compression ratio. With reciprocating engines, notably with the Atkinson engine, attempts have been made to overcome this disadvantage, but without success.

The case for the internal-combustion turbine is, however, not hopeless. Taking such working temperatures and pressures as can be realised in practice, a theoretical energy utilisation of about 67 per cent. would be obtained. The compression does not take place within the explosion chamber, but must be furnished by an outside compressor. The compression work is increased further on account of delivery work, theoretically by 40 per cent. Practically, on account of the many sources of inefficiency the increase is greater. Even with large units, the efficiency of turbo compressors is relatively low, and turbulence losses must also be allowed for. The efficiency of the turbine wheel, furthermore, cannot be assumed to be higher than 60 per cent., so that the theoretical figure of 67 per cent. is reduced to a practical one of 13·8 per cent., which is less than one-half of that of the modern internal-combustion reciprocator. The best-known application of the turbine principle to internal-combustion work in the past is the German turbine, the Holzwarth. Mechanically, this turbine was a success, but the energy utilisation could not be expected to reach a higher figure than 13 per cent. to 15 per cent. Holzwarth proposed later to use an exhauster, driven by exhaust raised steam, to draw the gas into his combustion chamber, and in such a way an overall efficiency of 20 per cent. may be obtained, which, in comparison with present-day turbine practice, does not promise well for the future of the explosion turbine on such lines.

A French development, that of Armengaud-Lemale, was successful up to a point. These gas turbines, whilst unsuccessful commercially, due to their inefficiency for power production, have been fitted in quantities, to drive torpedoes by utilising compressed air. The weight of this engine works out at 1·3 lb. per B.H.P. For aeroplane driving, where weight is of first importance, such prime movers have been considered, and Rateau is responsible for an interesting turbine, which utilises the velocity in the exhaust gases of the reciprocating Aero engine to drive a turbo compressor to supply under pressure the charge of air and petrol to the

main reciprocating engine, so compensating for the reduction in density of the air at high altitudes. As to whether such an auxiliary is a commercial proposition, depends entirely upon the ratio of the extra weight required to the extra power gained.

Practical considerations cannot be neglected. High temperatures must be dealt with, if reasonable efficiencies are to be obtained. Such temperatures as are normal with the reciprocating internal-combustion engine are very serious in a turbine installation, because of the practical difficulties in cooling the revolving members. Bladeless turbines may be evolved, blades of non-metallic materials have been discussed. Valve designs capable of dealing with high temperature gases may be produced. Internal water injection, as a means of reducing the temperature and increasing the power output, cannot be regarded favourably. Theoretically such a procedure has a considerable effect in reducing thermal efficiency, as is clearly shown by a series of curves in Mr. Norman's paper.

In this paper the author, whilst pointing to the difficulties towards an early realisation of a reasonable efficiency in terms of work output per unit of fuel consumed, is quite hopeful that a simple plant will be evolved in the near future, in which all the units will be of the turbine type, and where the efficiency overall will compare with that achieved by the present-day reciprocator. Very little of a definite nature is given to shed any ray of light along the probable path of progress, to serve as a guide to willing investigators. The most favourable case is felt to be that of a combination of steam and internal-combustion prime movers. It is proposed to utilise the heat transferred to the jackets to generate steam. This steam drives or assists to drive a turbo compressor and the heat remaining in the exhaust is partially given to the air delivered from this turbo compressor. At first glance, this may seem a somewhat complicated plant, but in practice it would probably be more simple than present-day reciprocating engines. Generally, such a scheme favours in measure the "Still" engine, about which much has recently been written. It is felt, however, that the practical difficulties are still to be faced and overcome and that much metallurgical research—unless actual discovery takes place—remains to be undertaken before a sufficient temperature range to ensure reasonable efficiency can be dealt with in a gas turbine. There is the demand, and although efficiencies fall somewhat short of those achieved with reciprocating internal-combustion engines, the engineer of to-day is educated to desire rotary motion and simplicity wherever possible, even at the expense of a slight loss in economy.

THE LAW OF PROBABILITY AND RESTRICTION OF OUTPUT.

During the war there appeared a Blue-book dealing with the question of industrial fatigue as affecting output. The publication contained the results of investigations carried out by Dr. H. M. Vernon upon the effect of the length of working hours upon the productivity of groups of workers, and although the conclusions agreed generally with the views held by enlightened employers of labour, the work was useful as a record of actual data collected over a large field. Blue-books, however, are very rarely read by engineers, and it may therefore be worth while discussing one rather important point arising out of the investigations, namely the possibility of the results being vitiated by wilful restriction of output. Obviously, if a body of workmen decided that they would not do more than a certain amount of work per day, a factor is introduced which upsets all calculations as to the effect of fatigue upon output.

It appears that this point was brought to Dr. Vernon's attention, and it became incumbent upon him to determine, if he could, whether any such restriction of output was taking place. He attacked the problem by a method which is certainly both ingenious and suggestive, namely by comparing the results actually obtained with those which would be indicated by the law of probability. He assumed that, under normal circumstances, the output of any worker is determined by the sum of a very large number of very small causes, such as conditions of health, strength, eyesight, dexterity, comfort, condition of machine, illumination, &c. Each of such causes is really the aggregate effect of innumerable minor causes, so that in reality the number of causes affecting the output of any worker may be called infinite. It is also logical to assume that there are as many causes acting to raise the output of a worker as to depress it, for example a man is just as likely to have health, strength or skill greater than the average of that of his fellows, as he is to be below the average in any of these respects.

Granting these assumptions, which we are logically bound to do, we are driven to the conclusion that the productivity of any large number of workers will follow the mathematical law of error. The few men of exceptional ability will be balanced by an equally small number of unusual dullness, and every grade of workers above the average will be matched by an equally numerous grade correspondingly below the average. Should this not be found to be the case, it would point to the existence of some extraneous factor interfering with the natural order of things. Thus any cause tending to limit the output of the naturally faster men would be reflected in a lack of symmetry of the curve of productivity.

Dr. Vernon applied the principle of probability by dividing the total number of workers engaged upon a given operation into a number of groups, each group embracing all those having a certain range of productivity. He noted the number of men in each group, and by plotting these numbers he obtained a curve reasonably symmetrical on both sides of the centre, and generally resembling the well-known curve of probability. He deduced from this that there was no limitation of output in the establishments which he was investigating, as had any such influence been at work he considered that it could not have escaped detection by the method of analysis he adopted.

The ingenuity shown in applying a well-known mathematical principle to a manufacturing problem with a view to providing a definite answer to one of the most difficult questions which confront a works manager is certainly to be commended. Yet we must not assume that we have been furnished with a test for restriction of output which can be usefully applied in any but very exceptional cases. Deductions from the law of probability are only found to be reasonably in accordance with facts when very large numbers are under consideration. With many hundreds of workmen all engaged upon the same operation and working under equal conditions, and with many thousands of operations under review, we might be justified in drawing conclusions from a comparison of their actual output with that which would be deduced from the law of probability. But, in general, the numbers we have to deal with are far too small. The records of several operations in a fair-sized shell factory were compared with the curve of probability, in the manner adopted by Dr. Vernon, and in no case was it possible to draw any useful inference at all. With regard to one operation the rather surprising discovery was made that hardly a girl performed the average number of operations. One large group had an output well below the average, and an equally large group on the same shift and working under identical conditions were doing substantially more than the average. No reason could be assigned for this, but the fact serves to show how unsafe a guide the law of probability is unless very large numbers are dealt with.

A further consideration which diminishes the usefulness of the method is that when such numbers of men are engaged upon repetition work as would justify the application of the law of probability, the value of their output is quite sufficient to warrant a very close time study of the operation. A capable production engineer will know from personal observation the detailed times necessary for the performance of every item of work going to make up the complete operation. With this knowledge he can determine what is a reasonable output to expect per day. Observation of the overall time taken to perform a complex operation is not by itself sufficient. The overall time should bear a reasonable ratio to the sum of the component times, as inefficiency of production, whether wilful or unavoidable on the part of the workman, is usually to be traced to delays, rather than actual slowness of work. In fact, a detailed knowledge of the time properly required for every operation is really the basis of efficient machine shop management, and it provides a far more certain check upon restriction of output, whether due to adverse conditions of work or to a false economic creed, than any mathematical generalisation.

REFORM IN CHINA.

Since the beginning of the Peace Conference the subject of reform has been much discussed, both in the native and European press in China, and though the preliminary to reform of any sort is the downfall of the military clique, who, backed by Japan, really rule the country, it is a matter of some interest to enumerate those reforms which would benefit engineering trades. The most important and most discussed reform is that relating to the management of the railways, and the following are the instructions given to the Chinese delegates in Paris as to the future railway policy. "All railways constructed, now under construction or to be constructed under existing agreements by foreign capital or foreign loans, shall be consolidated under one uniform management, and capital and loans shall be consolidated into a joint loan with the said railways as security. The Chinese Government shall employ foreign experts to assist the Chinese in the administration of the railways until such times as China shall have repaid the loan. All matters concerning transportation shall be under the control of the Ministry of Communications and subject to Chinese law."

The above is all very well in its way, and is undoubtedly a step in the right direction as regard abolishing spheres of interest and making the "open door" more than a mere phrase, but it is much too vague in its details as to the extent of foreign control. Taking the last phrase as to control of the Board of Communications, it cannot be too often pointed out that foreign control of the Board, that is by foreigners serving the Chinese Government, is an essential to efficient management of the railways. The appointment of advisers without power to insist on the carrying out of their suggestions is absolutely futile, as has been proved time and time again. For instance, Dr. Morrison, the late *Times* correspondent in Peking, and now political adviser to the Chinese Government, has been utterly unable to prevent the very rapid rise of Japanese influence in China, and has been unable to bring about a settlement in the civil war which has ruined China and is still far off from settlement. Dr. Morrison was to all appearances much more of a power in the country as *Times* correspondent.

That foreign supervision is needed is proved by the following instances of control by the present Board. Thus, take the case of its handling of the British loan of 1,500,000*l.*, lent for the construction of the Shanghai–Hangchow–Ningpo Railway in 1908. The people in the district traversed by the line are a truculent lot and very much resented the introduction of foreign capital, or for that matter any sort of control by the Board itself. As a consequence, to avoid trouble they were allowed to form two private companies with a total capital of some 800,000*l.*, to build a line which had been given to the British to construct as far back as 1898. With our usual masterly inactivity we allowed this, and awaited developments, which materialised in the rapid exhaustion of the Chinese capital, which had, of course, been wastefully administered, as was only to be expected when the only qualifications required from the engineers were a year's foreign education in engineering or being somebody's son or favourite.

Chinese funds being exhausted, the Board used the proceeeds of the British loan, utterly ignoring the fact that supervision of expenditure, as on the Tientsin–Pukow Railway, was required, and that requisitions for cash required foreign certification. In addition, the usual clauses as to the purchase of materials were not only ignored, but

in one case in connection with a tender for rolling-stock, it was stated that only tenders from German locomotive firms would be considered. Further, though a British chief engineer was appointed at a salary of over 3,000*l.* a year in order to comply with the agreement, he was not allowed to do anything, and spent the bulk of his time in Shanghai. That such things were allowed by the British Government is appalling, and that the fatal policy of the line of least resistance has been disastrous for British prestige in the Far East is not to be wondered at. Such happenings are primarily the fault of the Government, but they are in part due to the indifferent attitude, from the imperial point of view, of the British investor, who so long as he draws 5 per cent. on his capital is apparently unconcerned as to whether that capital is spent in Germany or Japan, when if properly looked after it should have been spent in England. Had the British investor been educated to take an interest in the spending of his capital, the squandering of this million and a half of money might have been prevented, for *The Times* correspondent in 1909 (February) fully exposed the whole scandal. Exactly what happened to the money will never be known, but presumably it was all spent in various ways, for the native companies only succeeded in completing 118 miles from Shanghai to Hangchow, and in partially completing about 60 miles at the Ningpo end. At the Shanghai end practically everything except rails and sleepers was bought in America, while at the Chekiang, or Ningpo, end, rolling-stock was bought from practically every nation under heaven, resulting in a perfect menagerie of types, most expensive, of course, to maintain.

The after history of the railway is as follows: The Shanghai–Hangchow portion and the partially-completed Ningpo section were run probably at a loss* by the respective private companies until 1914, when they were taken over by the Board of Communications and handed over to the British controlled Shanghai–Nanking Railway for management, who completed the construction of the 60 miles at the Ningpo end and started construction on the 60-mile section, which will connect Shanghai with Ningpo. Another instance of the need of foreign supervision might be taken from the management of the construction of the German section of the Tientsin–Pukow Railway where, in addition to grave scandals as to land purchase, defalcations to the amount of 500,000*l.* were discovered. In this case it is probable that there was a certain amount of German connivance.

As a last illuminating instance, as showing the way in which mineral concessions are handled, it would be as well to allude to the history of the Tung Kwan Iron Mine Concession. In 1902 an agreement was signed between the Chinese Government and the British concessionaires of the above for working an area of 45 sq. miles for a period of sixty years.

The terms for which this concession was granted were as follows: (1) The Chinese Government to receive 1 per cent. of all capital raised; (2) the Chinese Government to receive 22½ per cent. of any profits; (3) the Chinese Government to receive 5 per cent. *ad valorem* mining tax in addition to the usual maritime customs tax, a further 2½ per cent.; (4) the usual land tax to be paid. In addition to the above clauses the concessionaires were to contribute 1,000*l.* for philanthropic purposes, to take a share in the upkeep of the local schools and to start and bear all the expenses of a mining school. Further, if a railway was built to the mines the concessionaires were forbidden to equip it or use it for passenger traffic.

A concession on such terms could not fail to have resulted in great benefit not only to the neighbourhood, but in large revenue to the Peking Government, yet every obstruction was placed in the way of working the concession both locally and in Peking, so much so that it was finally abandoned in 1909 on payment of a sum of 52,000*l.* Subsequently the natives attempted to work the concession and miserably failed. At present if British claims are not looked after there is considerable danger of this concession falling into Japanese hands. The history of most mining concessions in the Yangtse Valley has been similar. They have been obtained on the very extravagant terms cited above, have been obstructed from the start, and finally bought out.

Thus in the case of the British Kiangpeiting coal concession in the province of Szechuan the concessionaires actually lost money to the extent of 30 per cent. of the capital invested, while in the case of the British Eastern Pioneer Company, working in the same province, no compensation was paid at all. In every case the Government and the people have been able to do nothing with the abandoned concessions. The Board of Communications has thus not only retarded the industrial development of the country, but has failed to carry out agreements made, and also deprived the country of much-needed revenue.

The need for foreign supervision is further emphasised by the present condition of this department, which has drifted into the hands of a clique whose sole idea appears to be that of enriching themselves. As a consequence only those who can stoop to pandering to corruption can hope to get anything out of the Board. This is the cause of the rise of Japanese power, as, of course, they had the money, made out of the war, and were not troubled by any silly scruples as to buying support for schemes treasonable to any patriotic Chinaman.

What can be said in defence of a department which allows the purchase of condemned rails, does nothing in the way of development work for open lines, has even allowed some of these lines to fall into a dangerous state of disrepair, and is further responsible for the loss of enormous revenue owing to failure to cope with the rolling-stock shortage and the soldier pest?

Turning to the question of loan allotment it cannot be too often stated that China must in future have one source only from which money can be obtained, for there is no shadow of doubt that the greed and jealousy which have characterised loan negotiations in the past have materially retarded the development of the country, as they enabled the Government to obtain money on terms which could only result in enormous waste and extravagance, in addition to added burden to the country, for the greater the relaxation of supervision of loan expenditure the higher the interest asked for.

As a typical instance of pre-war loan negotiation, take the case of the six-nation reorganisation loan of 1912. On February 17 of that year the Provisional Government of the newly-made Republic approached the representatives of the four banks supported by the Governments of Great Britain, France, Germany, and the United States, and suggested that these banks should undertake to finance China to the amount of 60,000,000*l.*, to be paid in equal instalments during the next five years. It was further suggested that the banks, to enable the Government to cope with a critical situation aggravated by the mutiny of the bulk of the Peking garrison, should at once advance about 100,000*l.* This was done, the respective Governments consenting, and on March 11 the banks agreed to finance the larger loan subject to certain guarantees, the most important of which was a provision for effective supervision of expenditure of the loan.

This was the last thing the republican Government desired, so an agreement was immediately concluded with a Belgian group supported by the Russian Government for an immediate loan of 1,000,000*l.* with the option of 9,000,000*l.* more. The interest on this loan was to be 2 per cent. higher than on the Four Banks Loan, and the only railway in the country built and managed entirely by China was to be given as security for the loan. The first million of the loan was actually paid over, but the Four Banks, finding that they were in danger of losing much profitable business, decided that it would be foolish to insist too much on the supervision clause, and so eventually consented to the appointment, as foreign auditor, of the German accountant of the northern section of Tientsin–Pukow Railway. Also as a further consequence the Four Banks, as the price of cancelling the Belgian loan, were compelled to admit Russia to participation in the loan, although neither she nor Japan, who obtained admittance by similar methods in connection with railway and shipping undertakings in Central China, had any capital to advance. In point of fact these two nations not only obtained the right to participate with money which would be supplied by either London or Paris, but they also obtained a guarantee that the proceeds of this loan should not be used to develop Manchuria or Mongolia to the detriment of their illegal special rights in those regions.

The above instance is sufficient to show the need of solidarity in matters of international finance in dealing with a country at the stage at which China now is. China must in future get her money from an internationally-controlled source and from nowhere else, or her development will be retarded, and the creation of the class of Chinaman capable of efficiently handling large enterprises indefinitely postponed.

It should be said here that this idea of freeing the railways from political influence, though indefinite in its details, has met with general approval in the country, the Japanese and those under Japanese control excepted—this party is, of course, doing its utmost to wreck the scheme, alleging that it will mean the domination of China by Great Britain and the United States. In refutation of this suggestion it is only necessary to instance the history of the existing Customs Service, on which China's credit rests, and which in spite of powerful international control has never endangered China's sovereignty in the slightest degree.

As a reminder of the extent of our interest in railway concerns in China, it should be stated here that the foreign debt for railways alone amounts to some 37,000,000*l.*, of which we have lent over 11,000,000*l.*, that we are further committed to the construction of some 720 miles, for which 6,000,000*l.* is required, and that we hold concessions for the construction of another 1,490 miles of railway. This capital and future capital, though perhaps small in comparison with our stakes elsewhere, should surely be efficiently looked after with a view to obtaining the utmost out of what we have or are about to invest, and also from the point of view of our hold on what will be one of the world's greatest markets. The policy of internationalisation would therefore appear to be not only the best in the interests of China, but in our own also, as China would cease to be the happy hunting ground of the purely selfish and denationalised financier who has been responsible for so much of our troubles and humiliations not only here but elsewhere. We should consider how Germany was allowed to rob us of the just development rights of the Smyrna Railway, how French support was obtained for the gigantic swindle of the Baghdad Railway, and how nearly German influence became predominant in Portuguese West Africa, all as a result of uncontrolled* stock exchange manipulation.

After railway reform the most needed reform is that in connection with mining law. In the first place the foreign holding in a Chinese mining company cannot at present exceed 40 per cent. of the total capital, and, further, with the exception of missionaries, and Japanese in the railway zone in Manchuria only, foreigners cannot own land in China. These two laws constitute an effectual bar to all industrial progress, for they imply Chinese control of Sino-foreign ventures, a condition not to be tolerated under present conditions.

In addition to the above laws the existing taxes on mining in China are three to five times heavier than in the United States, while the risks owing to a weak central government, local opposition, badly-defined boundaries, which cause interminable disputes as to land ownership, are infinitely greater. The following are the percentages of the average market value of the metal mined at present and extracted by the Government on various metals. These taxes, of which there are about five to be paid in as many different places, may be summarised as follows:—

	Per Cent. of Market Value.
Copper	7·6
Iron	13·64
Lead	8·63
Spelter	5·56
Tin	4·36

* No accounts were ever published.

* Uncontrolled as far as we were concerned, but very much the reverse in the case of Germany, whose finance has always had imperial aims and been directed by picked men—a policy we might well adopt.

Compare these taxes with the 2½ per cent. on gold and silver and the 1·8 per cent. on coal demanded from mining concerns by the Mexican Government.

Chinese explosive law should also be amended as soon as possible, as at present foreign companies requiring explosives are compelled to apply through the local provincial governor for a permit to import, and he again cannot grant such permit without reference to Peking. In Chinese hands, especially if not friendly, this becomes an intolerable obstruction. Further, the customs restriction on the import of saltpetre, a name which is loosely applied in China to many salts, and thus places a useful weapon at the disposal of the unfriendly official, in addition to those restrictions on the importation of sulphur, brimstone and spelter, all of which are at present Government monopolies, should be removed.

Lastly, the law, which demands inspection by a Government official of all mining properties prior to starting working, causes most vexatious delay and is another loophole for that passive obstruction so difficult to specify and at which the Chinese official excels.

It should be said here that Chinese mining law seems to have been drawn up regardless of the grave risks of all mining business, and with an altogether exaggerated idea, not only of the mineral resources of the country, but also of the fact that a mine is a progressively depreciating asset. Also China should be reminded that our treatment of her nationals in the Federated Malay States, not only in connection with mining, in which we have done everything to encourage the industry irrespective of race, but also in every other branch of industry, demands a *quid pro quo* in the shape of similar good treatment in China. It should not be forgotten that the wealth of the rich provinces of Kwantung and Fukien is largely in the hands of returned emigrants from the Malay States who made their fortunes there as a result of the security and equality of opportunity, given by our rule. China should be made to realise our power and also our great forbearance in our treatment of her in the past.

Other urgent reforms in connection with industrial development are those relating to likin and money. Likin is the interior customs tax in China, and its exaction is in no way regularised, and depends largely on the needs of local officials, who also have the power to increase the number of places on a trade route at which this tax can be levied. It is easy to imagine the barrier to industrial expansion constituted by such irregular and annoying taxation. In many cases the effect of numerous likin barriers have been to force all traffic to take less feasible routes with consequent advance in the price of imports brought by these routes.

With regard to the money question, in the remoter districts of China away from the railway zones, there is a multiplicity of standards most hampering to trade. Thus in one case, by no means exceptional, in a journey of 120 miles, the following standards of coinage were in circulation:—for the first 30 miles the standard silver dollar and notes were current, for the next 70 miles a Portuguese dollar of 1793 was in use, and for the remainder of the journey "cash," a brass coin of which 1,200 are worth about 1*s.* 8*d.*, was in circulation. The rates of exchange are continually fluctuating, and can be manipulated of course to kill industry to which officialdom is unfavourable. Further, the absence of reliable banks is a great handicap to foreign co-operation in Chinese concerns, for Chinese banking methods are much too risky to meet with Western approval.

Finally, in order to secure the co-operation of foreign capital, Chinese company law must be amended to make the payment of interest out of capital illegal. At present Chinese shareholders regard their holding in a concern purely as a loan and expect to get their interest as if from a mortgage. Under present conditions all sound sino-foreign concerns are compelled to register either in Hong Kong or London and incur the expense of office upkeep in either place.

THE TECHNICIAN.

SCIENCE, technics and practice are the three main divisions in industry, that is if science will allow herself to rank as an industrial division at all. Apart from this all material problems may be attacked scientifically, technically or practically; the distinction usually given between science and practice is that the first concerns itself with the entire range of a subject in sequence while practice is concerned only with the immediate issue. It will be seen, therefore, that technics occupy an intermediate position, for while science is unconcerned as to the results of gained knowledge, and practice devotes its exclusive attention to the affair of the moment, technics must give heed to both; its concentration is upon practical problems in the light of scientific result.

Hence the technician must possess a mind of a practical type of scientific training. As a matter of fact technics cannot be divorced from practice in any remote manner, for it is the results of practice which found technique. The technician must possess a firm grasp of fundamental principle, only when the results of practice are co-ordinated, assembled and digested can there be a technique of any subject, further than this the underlying principles must be rescued from the great mass of irrelevant material and shown in high relief.

The technician is broad or narrow, precisely as the field wherein he works, possibly the broadest field may be termed constructive engineering, the narrowest, some specialised craft sub-section. To deny the title of technician to a specialist would be to falsify the basis whereon broader technics is founded. Take two instances, both modern, gearing and grinding; there are men in both fields whose grasp of essentials and practice is extraordinary, or that of heat treatment of steel apart from the general province of metallurgy; such individuals are as minute in method as fertile in origination, as competent to track down the factors in any given case as any scientist.

Such men are technicians in the fullest sense of the term, for their specialised endeavour demands large resources of knowledge and the formulation of underlying principles. As time passes, the specialised technician becomes more and more pronounced in every industry. The lapse of a few years and the abstruse problems yield to patient endeavour and become simpler, the principles discovered and another chapter is added to mechanical evolution, those who have followed the developments in process of the last decade must understand what is meant. Such technicians are more closely allied to the scientist than they would themselves credit.

The broader type has more elbow room, for although his concentration is not less intense the component minutæ are of greater visibility until we come to the modern engineer in any field, who is more co-ordinator and less the detail expert. Whether he be concerned with production, construction, design, organisation, power or mechanism, he works largely upon faith in specialised activity, the results of which he comprehends but which he would be unable to carry out personally.

In every case personal and original mentality is exercised, and this differentiates the technician from the craftsman, although it may frankly be stated that brains are needed in every capacity, however humble in the engineering field. Still the distinction must stand, for technics is the application of principle to practice in an individual capacity without exact duplication or repetition.

It matters little with what actual materials the work is done, whether with lines on paper, on the test bed in the laboratory, or the actual shop, there are technicians in all capacities, as there are mechanics in all. The commercial is alone excepted, for although there is a technique of business it is not technical from the present point of view. The fact that a man draws for a living does not make him a technician, he may detail to instructions, if he estimate it may be from pure precedent, he may be employed in a technical category and yet do routine work. The distinction is really whether he continuously exercises original thought on novel problems, applying principle to practice.

While every man in the industry is the better for theoretical knowledge, the training of the technician, competent and able, is a matter which has exercised the minds of the most able in the profession. To be a technician is not to be an exclusive, his work must inevitably dovetail into that of others. As a consequence its beginning at least must be broad and comprehensive. It is one sterling merit of the vast territory described as engineering effort that it is truly democratic and nothing will make it otherwise, it matters little in what capacity entrance is effected, it matters a great deal as to the quality of the entrant, granted intellect and capacity there are endless possibilities to the enterprising who will fit themselves, the witness to the truth of this is to be found in the biographical notes in the engineering press. This fact alone has furthered the path of evolution until there is no other business which can claim the same progress in an equivalent period of time.

The opportunity to become a technician in the fullest acceptation of the term is denied to none, and while systems of training smooth the pathway there is yet no royal road to make an engineer.

The new spirit abroad in industry to-day has led to a new appreciation of the man who can tackle unusual problems with success, and some surprising discoveries have been made; it is to be hoped that this new feature in industry will be permanent in its effects, for it must be admitted that in the past a competent technician could be hired often at less than the pay of a machine-shop operator, and his treatment be about equivalent thereto.

It is, of course, a mistaken notion altogether that technical attainments are of value only in the drawing office, and in this connection it is remarkable that the position of shop foremen (a most responsible post) should in the past have been shunned by the competent technician, trained to this end. Experience in the capacity indicated is of very real value in production. There has, perhaps, been some blindness both sides—on the part of the trained technician on the one hand and the management on the other. The value to both sides would be considerable, for in no other capacity can the same view-point be obtained. Instead of being as it is at present a dead end, it should be a natural and evolutionary step of distinct value.

Engineering industry minus the technician would still be a trade, and an important one, but it would crystallise instantaneously and stagnate immediately. His functions are of real and immense importance, and the attention focussed on his efforts in the recent period has only served to establish his real worth. That as many men of considerable mentality were under the old conditions willing to continue considering the value of trained brains elsewhere is, all things considered, remarkable. It was the call of the business to the constructive mind, and whatever else may be said monetary gain was not the main incentive.

Every man associated knows the interest that engineering effort compels, and there has never yet been any lack of suitable candidates for one of the most strenuous fields of effort known to civilisation. Engineering underpins the modern world, and to a very great extent the technician underpins the industry, without him there would be collapse and failure, even with his aid there are troubles enough in all conscience to keep him busy.

EXTINGUISHING AND PREVENTING OIL AND GAS FIRES.

DURING the ten years, January, 1908, to January, 1918, approximately 12,850,000 barrels of oil and 5,024,506,000 cub. ft. of gas were destroyed by fire in the United States. The 503 fires caused the death of 150 persons and permanently disabled many more, and the property loss amounted to 25,254,000 dols. Of the fires 310 were attributed to lightning and 193 to other causes. In parts of Oklahoma and Texas oil fires have become so common that the people almost regard them as an unavoidable evil; during one summer week of 1914 lightning destroyed 86 oil tanks, up to 55,000 barrels in capacity, and the total damage done to these tanks and the equipment was estimated at 1,000,000 dols. Some of these cases, generally ascribed to lightning, might more correctly perhaps be attributed to electric sparks, being only indirectly or not at all connected with thunderstorms, as we shall see. But atmospheric electric discharges are undoubtedly responsible for most of these fires which are far more common in summer than in

winter. Since we cannot control the accumulation of atmospheric electricity, the first question is how to extinguish an oil or gas fire that has broken out; the consideration of observations made during such fires may suggest preventive measures.

The most common and convenient extinguishing agent, water, puts the fire out because it cools the flame while being evaporated, and forms a cushion of incombustible steam over the burning mass which smothers the flame by shutting out the oxygen. But water and oil do not mix with one another; when the first direct cooling effect fails, the burning oil floats on the water and may be spurted about and carried away and spread the danger. The fire is therefore often at once attacked by steam which is fed into the oil tanks by 2-in. or 3-in. pipes. In closed all-iron tanks the steam will answer, as long as there is no hole somewhere or some minor explosion allowing the steam to escape; when the tanks are covered with wood, the burning wood may re-ignite the oil. For these reasons the frothy-mixture extinction has become popular in America, though it involves the laying down of proper extinction plants. We described the frothy-mixture system, the Schaumlöschverfahren Perfekt, of Berlin, in our issue of January 17, 1912, and referred in subsequent Notes (March 21 and April 15, 1913, pages 401 and 536) to successful trials of the system in London and in the United States. The essence of the method is that two solutions—one of sodium carbonate or bicarbonate to which some frothing material is added, the other of alum and sulphuric acid—are mixed at the moment when wanted. The alumina and soda, together with the frothing agent, form a heavy blanket on the burning surface over which they are spread, so that the fire is stifled. The froth must last a sufficiently long time to prevent spontaneous rekindling of the fire. So far as possible the distribution of the froth mixture should be automatic, for the fight against fires of oil and natural gas is exceedingly dangerous, and the extinction plant should therefore be well designed. The installation put down by the Associated Pipe Line Company, of Coalinga, California, exemplifies this. The installation is fully described and illustrated in Bulletin 170 of the United States Bureau of Mines. This publication, drawn up by C. P. Bowie under the title of this article, is a very instructive paper which gives also much useful information on other methods by which oil and gas fires have been fought and can be prevented.

The two solutions used at Coalinga consist A of 10 parts by weight of crystallised aluminium sulphate, half a part of sulphuric acid (66 deg. Bé) and 100 parts of water; and B of 7½ parts of sodium bicarbonate, 1½ ground glue, ½ glucose, $\frac{1}{32}$ arsenious oxide, to 100 water. The bicarbonate gives carbon dioxide, which itself stifles the fire; the glue and sugar keep the aluminous froth sticky. The object of adding the arsenious acid (or oxide) is not explained; it may have been an accidental impurity in the first instance, to which the company afterwards adhered; it may be added to prevent fouling of the glue, in the place of the salicylic acid and other sterilising agents of other mixtures. But it seems to be a very undesirable ingredient; the arsenic would pass into the oil and into the gases and vapours from lamps, &c., and arsenic is most dangerous in the gaseous state.

The Coalinga plant is to protect four 55,000-barrel tanks (114½ ft. diameter) and several smaller oil and fuel oil tanks (the latter 8 ft. in diameter), of about 120,000 barrels altogether. Assuming that 1 gallon of solution gives 6 gallons of foam, and that a blanket 5 in. thick should be supplied in 5 minutes, 6,200 gallons of each solution would be required to cover all the oil once with 5 in. of foam. With a liberal safety allowance two solution tanks, each of 15,700 gallons, have been installed, made of galvanised iron, all seams riveted and soldered. The acid tank A is lined with lead; the roofs are wood. The delivery of the solution is by two centrifugal pumps—hardly the best pump type for proportioning the liquids—each driven by a 110-h.p. steam turbine; the impeller of the acid pump is made of acid bronze. The soda tank is placed immediately above the acid tank; the pumps discharge into a pipe system fitted with five 5-in. valves, the stems of which are so connected by sprocket chains that solutions A and B are simultaneously, and at the same rate, discharged into the mixing box. Each oil tank has its own mixing box placed on its outside so that an accident in the tank need not destroy the box and pipe system. In order to insure that the foam would not coalesce before reaching the oil level when low down in the tank, foam slides fitted with baffles were originally provided; but it has been found that the foam will bear a drop of 20 ft. and more. The solutions are steam-heated and agitated during the preparation. The plant was laid down in 1914; the cost complete is stated to be only 8,500 dols., including turbine, pumps and pipes, which would be about 3 cents (1½*d.*) per barrel of oil protected. The works being an oil-pumping station, steam is always kept up, it should be mentioned, and no extra foam pump is wanted, so that the maintenance costs very little. As it happens there has been no oil fire at Coalinga, and the plant has not yet been put to any practical test; but the plant is inspected every week, and has been thoroughly tested to satisfaction several times.

A fire was, however, extinguished by a similar plant of the Gulf Refining Company, Port Arthur, Texas, on July 19, 1916. Daily inspection is the rule there, and on approach of a storm the brigade men are sent to the pump houses. At 10.50 a.m., of that morning, three tanks were struck by lightning, two of 6,000 barrels and 7,000 barrels (the latter containing gasoline distillate), the third (90 ft. by 30 ft.) of 33,700 barrels capacity containing 28,400 barrels of gasoline at the time. Lightning probably struck the second tank, which blew its wooden roof off and set fire to the others. The foam was first sent to the third tank, the fire in which was extinguished within 20 minutes; 10 minutes later the fires in the other two tanks, to which the foam does not appear to have been admitted till 11.10, were also out. Opportunities were favourable for watching the fire in the second tank, and it was seen that the 6-in. blanket quite covered the tank within 5 minutes and that everything worked as expected, although this was the first time a fire was fought. Only 191 barrels were lost altogether.

The roofs in question were built up of wood and roofing paper, and Bowie points out that all the tanks reported to have been struck by lightning had such roofs or leaky iron roofs through which hydrocarbon vapours would be able to escape. It is quite likely indeed that local sparking may cause a fire, especially when the air is highly charged with electricity, without actual lightning. After lightning flashes, pillars of fire have been observed before the actual oil fire started, and in some cases oil has been found burning quietly, though there had been no lightning and the roof was found intact. Bowie, in this connection, draws attention to recent cases of fire observed in garages at Boston. A chauffeur suspended a 5-gallon can by its wooden handle from the hook of the gasoline pump; suddenly he heard a snapping noise, and the can was in flames. He managed to extinguish the flames; but when he started refilling the same can, it burst into flames once more. Filling a gasoline tank through a rubber hose has also caused fires, no doubt owing to static charges which accumulated until a spark jumped from metal to metal, from the can to the pump or from the nozzle of the rubber hose to the tank. To overcome the dangers of atmospheric discharges, the Texas Company builds its storage-farm tanks gastight, all in steel, and provides them with a 12-in. vent which is carried from the roof down to the ground and along the ground, beyond the ditch and earth mound surrounding the tank, to a standpipe, 10 ft. high. A piece of wire gauze is fixed over the outlet of the standpipe; all the vapours from the oil in the tank escape through this pipe, and if it should be struck by lightning, the flame would not as a rule strike back into the pipe. In case it might do so, however, the tanks are provided with explosion doors which, when forced out, would fall back into position and shut out the air. So far none of these tanks has been struck. Bowie thinks of absorbing or condensing the vapours; that, however, might frustrate its object.

Arrangements of the kind described can hardly be made to anticipate fires of gas-wells and oil wells, and the expedients used there must be adapted to the particular circumstances, and are sometimes peculiar. When the gas flow is confined in one stream from a pipe or casing, the problem is easy. The flame, unless very small, will always be some distance above the casing, and when the gas pressure is high, there will be a column of non-burning gas of considerable length. An energetic stream of water or steam is directed against this column, and if the gas column is once interrupted by the steam or water, even a big flame will be extinguished. When the gas and oil also escape from several spots, however, for instance through a leaky valve, below the outlet, the problem is more difficult because everything gets too hot. In one of these cases the Standard Oil Company at Taft severed the pipe below the valve by means of rifle shots; it took 40 shots to do this. When steam is to be used it is customary to surround the burning well with portable boilers—as many as 30 have been brought up—and a system of goose-neck pipes which gave a powerful fan spray. The men working the steam are protected by sheet-iron and asbestos shields and are frequently themselves kept soaked. By the aid of sprays meeting one another at 90 deg. a burning well was extinguished in Monroe, Louisiana, in 1917, which was credited with sending 40,000,000 cub. ft. of gas into the air daily; the shields were pushed up within a few feet of the fire.

The hood method of H. O. Ballard, of the Empire Gas and Fuel Company, works on the candle-extinguisher principle. By means of rope and tackle a conical hood is put over the flame; this hood is provided with valves and ends above in a long smokestack pipe. This was 20 ft. long and had a diameter of 14 in. in one case illustrated in the Bulletin. When the hood is in vertical position, some valves are closed; the pipes may have to be extended to a safe distance before the valves are manipulated. At Tulsa, Oklahoma, an oil operator, M. Moore, stifled in this way a gas fire which consumed 40,000,000 cub. ft. of gas in addition to 500 barrels of oil daily. The conditions were favourable because the well was in the bottom of a river bed across the banks of which a cable line for the hood and the 30 ft. of 36-in. smoke stack could be stretched. Oil-well fires are, on the whole, the most dangerous, since the ground is dried up and made so hot that the flames keep on rekindling. In the Humble field, Texas, C. P. Clayton stifled the fire of a flow of 6,000 barrels daily in the following way in 1916. The well being located in heavily-timbered country, he first cut down adjacent timber, stumps, &c., brought up 29 boilers for an extensive pipe system, and surrounded the well by a ditch and mound, 50 ft. in-radius. Another circular ditch and mound were built further off to secure the oil after being caught, and the two ditches were connected by a straight mound, 218 ft. in length; this straight mound served as conduit for a 36-in. smoke stack into which the oil stream was to be deflected. When the preparations were ready, a wedge nipple, 8 in. in diameter, asbestos lined, was placed over the spray of burning oil which was being discharged from a tool joint. This nipple was joined to a horizontal 3-in. pipe which was worked by the men from behind their shields, until the flame was made to enter the buried smoke stack, where it died, everything exposed being kept soaked all the time. Conditions must have facilitated the work, which was completed in 17 hours; the actual quenching of the flame took only 15 minutes.

In another case Clayton had adopted entirely different measures. A well, subsequently found to give 48,000 barrels of oil daily, had been ignited by the spark of a broken power cable. For six days, 36 boilers in vain flooded the well with steam; the burning oil spread to a distance of 100 ft. from the well. Something else was then tried. The well was on a hillside. A horizontal tunnel, 4½ ft. wide, 328 ft. long, was driven through the ground so as to strike the outer well casing 18 ft. below the surface. There were three casings, of 10 in., 8 in. and 6 in. respectively; a split clamp was put round the outer casing. With the aid of a chain drive and a special

4-in. case-hardened bit, which had a 2-in. hole in one of its sides, a hole was bored through the three casings; when the bit was in the centre of the casing, it was turned so that the hole mentioned, so far on the upper side, looked down into the well. The bit had been joined to a length of piping reaching out of the tunnel, and through this piping asbestos shavings were forced into the inner casing under a pressure of 1,200 lb. per square inch; the casing was thus temporarily sealed by the shavings. After a few minutes the bit was turned again so that the hole looked upward. When the oil which had collected within the mound surrounding the well mouth had burned out, the fire was over. But it had been burning for 26 days! Very interesting is also the expedient which M. E. Lombardi, of the oil department of the Southern Pacific Railroad had adopted, in 1913, in the Midway Oil Field, California. The well had been drilled by the rotary system on the downward slope of a hill, and had caught fire, after the premature outbreak of oil, while the rotary table was still in its place. This table formed a baffle, and the oil spurting out produced a crater 50 ft. wide and 40 ft. deep. Steam extinguished the fire, which always broke out again, however. The ground was a heavy clay; Lombardi excavated a clay pit some 200 ft. from the well and 30 ft. above it on the hillside, and had a ditch dug from the clay pit down to the well. The pit was filled with a fluid mud which was discharged down the well, three times in rapid succession. That stopped the fire, but only on its sixteenth day.

Many fires are, of course, hopeless from the beginning, and prevention by care is easier than cure. Insulating handles and hoods for cans and bails should be avoided, and the metal of the funnel should be electrically connected with the tank and the ground, by a metal chain. The Steel Company, of California, earths the tank in the garage. The nozzle of a hose should be kept in actual contact with the metal of any tank being filled. Big tanks should be all built of steel and pipe lines earthed; suction pipes should be provided for emptying tanks from below; and all measures taken, of course, to keep fires and electric sparks away from the oil and gas. Frothy mixtures will do well in garages, where sawdust, even dry, also renders good service, because the fumes stifle the fire. Carbon tetrachloride and other extinguishing agents are also useful. But caution is the first essential.

NOTES.

VELOCITY OF SOUND AND THE SPECIFIC HEATS OF AIR.

IN 1905 T. C. Hebb, now of the University of British Columbia, then at Chicago, determined the velocity of sound by a new method which seemed to give very accurate results. The method implied a certain value for the ratio of the specific heats of air, at constant volume and at constant pressure, which ratio is generally expressed by the symbol γ. It resulted later that this γ, as calculated by Moody, 1·4003, was smaller than the value generally assumed and especially the values obtained by various observers using the method of Lummer and Pringsheim, who themselves found $\gamma = 1{\cdot}4025$. Hebb recently pointed out (*Physical Review*, July, 1919) that Moody had neglected to make one correction, and that he himself had failed to apply another correction in deducing the velocity of sound in dry air at 0 deg. from observations made in moist air at some other temperature. He therefore repeated his determination of the velocity of sound with the same apparatus which he had used in his former experiments in the Ryerson Laboratory of the University of Chicago, to which Hebb returned for his new series of experiments. Two co-axial paraboloid reflectors and two telephone transmitters were used. The one transmitter was placed in the focus of the first paraboloid, the other near the focus of the second paraboloid. The source of the sound was placed in the focus of this second paraboloid which was kept stationary whilst the first was moved, always remaining co-axial with the first, however. Each transmitter was in series with a battery and one of two primary coils, the telephone receiver being in series with the secondary of the two primary coils. When the second paraboloid was being moved, the sound in the receiver passed through maxima and minima in positions corresponding to the wave-lengths of the sound used. The range of motion was about 100 ft. The experiments were made in a closed hall protected against wind, and thermometer and hygrometer measurements were made at 11 spots. In the old experiments Hebb used a whistle as source of sound; in the new series he made use of a set of tuning forks ranging in frequency from 1280 to 3072 periods per second. The mean value for the velocity of propagation of sound V_0 in dry air at 0 deg. thus found was 331·26 m. per second, in very close agreement with the mean value of 1905, 331·29 m. But the above-mentioned correction required for the conversion of the data observed in moist air to dry air slightly weakened the agreement. When allowance was made for the fact that the ratio of the two specific heats is not the same for moist air as for dry air, the new and the old values of the velocity of sound were respectively 331·44 m. per second and 331·38 m. per second; yet the agreement remains very satisfactory. As regards the value of γ the old and new determination yield the figures 1·4026 and 1·4031 when all the corrections spoken of are made, whilst Moody had in 1912 calculated 1·4003. The mean of the two values of Hebb would be $\gamma = 1{\cdot}40285$, which is almost exactly the value which theory would lead one to expect for a gas like air which may be said to consist of 99·05 per cent. of oxygen and nitrogen and 0.95 per cent. of argon. The values of γ found by other observers are: Lummer and Pringsheim 1·4025, Moody 1·4003, Partington 1·4034, Miss Shields 1·4029—all these by the Lummer-Pringsheim method, whilst Hebb deduced his γ from the determination of the velocity of sound.

GLYCERIN MANUFACTURE BY THE FERMENTATION OF SUGAR.

It has long been known that the ordinary alcoholic fermentation of sugar yields about 3 per cent. of glycerin, and the study of the fermentation has shown that the conditions favouring a rapid fermentation, by the selection of a suitable yeast and by feeding the yeast with nitrogenous compounds, also favour the production of glycerin. Under ordinary conditions there is little object in increasing the glycerin percentage; when the explosive industry found a valuable material in glycerin, the fermentation process received further attention, and some glycerin was, in fact, isolated from the distillery residue before the war. But the fermentation process for the manufacture of glycerin was not worked out until the blockade deprived Germany of the imports of fats. It was rumoured during the war that the protol of the Protol Company was a fermentation glycerin due to the researches of Lüdecke and Connstein. Particulars were not published, but they have recently been given by Connstein in the *Wochenschrift für Brauerei* of May 10, 1919. It would appear that as many as 63 factories were at one time engaged in this glycerin manufacture, but that only a few persevered with it. Yet an output of 1,000 tons per month is spoken of. The first important fact established by Lüdecke was that to produce glycerin, the fermentation should proceed in the presence of an alkali, and that sodium sulphite, a relatively inexpensive alkaline substance, answers very well. This sulphite has the advantage of not injuring the yeast, which is very sensitive to some chemicals. A solution of 1 kg. of sugar on 10 litres of water, to which 400 grammes of the sulphite are added together with the usual food for the yeast, alkali phosphates and sulphates, was completely fermented by 100 grammes of yeast in a few days. Quantitatively the products were 20 per cent. and more of purified glycerin, 27 per cent. of alcohol and 3 per cent. of aldehyde. There is, of course, always considerable evolution of carbon dioxide. In general the glycerin percentage rises with the amount of sulphite present, whilst the alcohol percentage decreases at a roughly corresponding rate. To separate these products the yeast is filtered off; the alcohol and aldehyde are recovered by distillation; most of the salts are precipitated by adding calcium chloride and sodium carbonate to the liquid and are therefore partly recovered as well, and the glycerin is finally obtained by distillation. This latter distillation is not free of difficulties, as is the case also when glycerin is manufactured in the ordinary way by the decomposition of fats; the new process had other serious difficulties to overcome. On the other hand, it is said that any sugar and also molasses and any kind of yeast will do, and that the fermentation temperature has practically no influence; the yeast, though modified, can be again used. These statements do not quite agree with the results of experiments which were started in the United States by J. R. Eoff, W. V. Linder and G. F. Beyer, of the Internal Revenue Bureau, when information about the German process had leaked out. An account of these researches was given by Arthur R. Ling in the Journal of the Society of Chemical Industry (London) of May 31 last. The American experimenters recommend pure cultures of saccharomyces ellipsoidus (var. Steinberg) and 5 per cent. of sodium carbonate gradually to be added to the sugar solution fermented at a temperature of 30 deg. or 32 deg. C., and they are, on the whole, more restricted as to the conditions of the fermentation. They worked with Porto Rico molasses, known as "black strap," but their glycerin was not pure, and the financial chances of the process did not look favourable. The cost was not mentioned in the German publication; probably protol is merely a war industry. At the same time Ling very properly points out that in Australia and Fiji molasses are at present discharged into the sea, and that a recovery of both the alcohol and glycerin would alter the aspect of the problem, as the American workers had also recognised.

THE NATIONAL PHYSICAL LABORATORY.—The Lord President of the Council has appointed Professor Joseph Ernest Petavel, D.Sc., F.R.S., M.I.Mech.E., &c., to be Director of the National Physical Laboratory in succession to Sir Richard Glazebrook, C.B., F.R.S., who retires on reaching the age limit on Spetember 18 next. Professor Petavel is Professor of Engineering and Director of the Whitworth Laboratory in the University of Manchester. He is a member of the Advisory Committee for Aeronautics of the Air Ministry. He was educated at University College, London, and undertook scientific research at the Royal Institution and at the Davy Faraday Laboratory until 1898. He was elected John Harling Fellow of the Owens College, Manchester, in 1900, and was scientific manager of the Low Temperature Exhibit of the British Royal Commission for the St. Louis Exhibition, 1904.

ATTACK OF POWDERED GLASS BY WATER AND ACIDS.—In testing the stability of various glasses when in contact with water and chemicals, it is customary to powder the glass so as to hasten the solvent effect by increasing the surface on which the water can act. The tests are further conducted in boiling water or at higher temperatures. Both the powdering and the high temperatures are certainly open to objections, and the tests can hardly give comparative results, when they are not performed under the conditions to which the material will subsequently be exposed. That objection is raised against all accelerated tests. In the *Comptes Rendus* of August 18 last, Paul Nicolardot recommends series of tests, conducted at temperatures of 100 deg., 120 deg., 140 deg., 160 deg. C., such as he performed in 1916; only in exceptional cases would he go to temperatures of 183 deg., which Mylius uses at the Reichsanstadt, as Nicolardot considers this temperature as altogether excessive. The tests of various French and other glasses of which he gives particulars were, however, made after three hours' boiling of the glass, in water or in hydrochloric acid. He takes either whole glass blocks or powdered glass, sifted through screens, which he distinguished as coarse, medium and fine powders; his figures express the loss of weight in parts per 1,000 parts of glass. The figures were for a Jena glass, whole, coarse, medium or fine powder respectively, 0·09, 0·25, 0·75, 2·75; for a Krasna glass, 0·44, 4·25, 9, 61·5; these were the best and the worst glasses tested. In the diluted hydrochloric acid the figures for the Jena glass were 0·03, 2, 5, 40; for the Krasna glass, 0·03, 2, 6, 49. Thus the attack increased very much with the fineness of the powder. When the loss of weight is reduced to unit surface, however—so far as this is possible by estimating the surfaces of the powdered particles—the attack remained fairly constant in the case of water, the increase in the loss of weight suffered by the fine powdering being slight. This is, of course, the argument on which the advocates of the accelerated tests rely. But the argument does not hold for the acid, in which the fine powders all lost two or three times as much in weight as the whole glass, and all more generally than in water. The results are contrary to expectation in two respects. First of all, water is believed to attack the whole glass of glass vessels as much as acid, if not more, and, secondly, one does not see why the fine powdering should have so markedly a stronger influence in the case of the acid, in which, moreover, the difference between the different kinds of glass were far less striking.

LITERATURE.

Shore Processes and Shoreline Development. By DOUGLAS W. JOHNSON, Associate Professor of Physiography, Columbia University. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd. [Price 23s. net.]

SEVERAL works have appeared lately on the subject of coast erosion and protection, but dealing rather with the cumulative effects of wave action in altering the configuration of the shore line, than in tracing the origin or the mode of operation of the forces at work. Royal Commissions have listened to much expert evidence on the subject, have deliberated on the proper means of preventing further depredations, and in bulky reports have tendered much good advice and very little assistance. These are signs that public attention is aroused and, indeed, in some districts the condition of the shore defence forces itself on the notice. The demolition of the coast line has in places proceeded with such rapidity that owners see their landed estate slipping away, but knowing that the cost of preservation would exceed the value of the land, they watch its disappearance philosophically, conscious that the anxiety is being transferred to the proprietors of hinterland. In other places, the depletion of shingle beaches has been carried on with such reckless avidity that coast authorities may well ask for further powers of restraint. The recovery of sea-swept lands occasionally makes amends, and then advocates for afforestation see their opportunity. The consciousness of pecuniary loss or the hope of beneficial returns from re-claimed land ensures a perennial interest in this subject, but Professor Johnson is not concerned with the economical side. He wants to understand the natural processes at work. He has asked for information and been disappointed by the repetitions and contradictions that too often supply the place of rigorous and well-directed observation. He has looked for precision and accuracy and found vagueness and confusion. An enormous mass of detail has been collected, but it is ill digested and lacks examination; generalizations have been made from too limited data, and insecure premises have led to mistaken conclusions. Even the nomenclature adopted is by no means uniform or consistent. The author states that an extended analysis of the forces operating along the shore with a full and systematic discussion of the cycle of shore-line development does not exist; and we believe this to be true.

The author's task to remedy this defect has been heavy, and we highly appreciate his laudable effort of collecting into a compact form the mass of crude and scattered theories and observations that have accumulated round this subject, and are too often quoted and accepted as authentic. The list of consulted works, attached to each chapter, constitute a valuable bibliography, and one that testifies to the thoroughness and industry of the author. We see here, of course, only the facts that the author has considered it desirable to retain, we know nothing of the mass of diffuse and inaccurate conclusions that he has rejected. An enormous amount must have been discarded, and the weeding-out process might, we think, have been carried further. Emphasis is occasionally lost by too large a collection from mediocre writers, while the reasoned inferences and deductions of weighty authorities are liable to be overwhelmed by less capable or less instructed opinion, though it must be admitted that the highest and most respected scientists not infrequently contradict each other, with results that amuse as well as perplex.

To trace the construction of a wave, even under normal conditions, is by no means a simple task, still less that of following its changing behaviour and character as it breaks on the shelving shore. It is easy to say that unequal atmospheric pressure deforms the water surface, creating irregularities of level, permitting the wind to press more heavily against the exposed positions and less effectively on the partially protected depressions, resulting finally in regular undulations, but we may be a long way from understanding how a wave is formed and the motion of its component particles. Yet if we would know how a wave acts in fashioning a shore outline; we shall not think Professor Johnson's description unnecessary or too prolix. Whence comes the energy the wave is capable of exerting, for the individual particles move through a comparatively small distance, a distance, moreover, that diminishes with great rapidity with increase of depth; and how is this energy transferred, for it is only the form of the wave that moves? The kinetic energy arising from the orbital motion of the particles cannot be initially very large, and this is equal to the potential energy due to raising the centre of gravity of the entire mass slightly above the position occupied when at rest. Without further examination these sources seem inadequate to explain the rearing of the steep wall of water that is occasionally seen thrown against an obstacle; or incapable of removing blocks of rubble cement weighing several hundreds of tons. On the other hand, accepting the force of waves seen in times of storms, it is equally difficult to understand from the same superficial examination, why the damage wrought is not greater and the destruction of sea walls and cliffs more rapid. On such points the author's treatment is not satisfactory; he is content to refer the reader to treatises, more mathematical in character, an easy but disappointing manner of shifting a difficulty.

If the intermittent character of oscillatory waves presents problems that tax alike the analytical power of the mathematician and the mechanical ingenuity of the engineer, the work of the constant current in coast sculpture is still more complicated. The operations of the quietly-flowing current, though less dramatic in action, are quite of equal importance, but more likely to be overlooked. In ordinary waves, the motion of the water is to and fro, replacement follows removal with monotonous regularity. In waves of translation there is some continual forward movement succeeded, however, by a halt, but a current of water moving in a definite direction carries on the work of transportation uninterruptedly. The eroding and conveying power of such currents is enormous, and even in tidal currents, notwithstanding the motion is periodic, the transport longshore of the debris eroded by wave action is very considerable.

Professor Johnson points out, and as we think with justice, that the work of the tides in moulding the shore line and in beach construction has been exaggerated, except in the case of headlands and estuaries, where, possibly, the effect of tidal flow has been underrated or misunderstood. Much of the deposited material existing in the form of fine sediment has been assigned to fluvial origin, but closer examination proves that the sea, and not the rivers, has transported much of these accumulations that prove so troublesome to harbour authorities. The tidal currents charged with sediment sway up and down the estuary, depositing their burden in some places at times of slack water, and eroding other places when the current is swiftest. Accumulations are always being diminished by an amount conveyed eastward, and as constantly renewed by fresh accessions borne towards the land. If the amounts balance each other, as probably is the case in the Severn Estuary, little dredging is necessary; if the inward flow exceeds that removed, as in Liverpool Bay, the harbour engineer has trouble.

But this is a detail into which it is most imprudent to enter. The point we wish to make is that it is very easy to misconstrue the work of even an isolated current. But add to such an agent the combined effects of wind currents, ocean currents, convection currents, salinity currents, eddy currents and many others, remember that all these vary in phase, in period, in strength as the outline of the shore changes, they approach the shore, too, at different angles and act on material differing greatly in solidity and cohesion, and the task of unravelling the work of each is at times impossible. In the past many mistakes have been made in the forms adopted for coast protection, because it is very difficult to get the true resultant of the many forces at work. Those who have had the largest experience will view with the greatest leniency the errors of others, for in no branch of engineering are the forces developed and the methods and directions of their application more variable than in the case of wave and current action, and the engineer has little collected experience to guide him. There is, in fact, scarcely an important point connected with the subject that is accepted without dispute, while the opinions and even the recorded observations of skilled engineers are often to all appearance in hopeless conflict. How great was the uncertainty attaching to some accepted beliefs, and how imperative the necessity for sifting and overhauling, we had not appreciated till Professor Johnson confronted us with actual quotations from leading authorities. The author must not expect to escape scatheless from the criticism of colleagues. All his conclusions will not be accepted; but this is not the place to enter into profitless controversy, which does not admit of final decision. Professor Johnson's work has this very positive merit, that it has lifted the subject to a distinctly higher plane, permitting a more general survey, and this wider outlook is assisted by sweeping away much irrelevant matter leaving the issues as clear cut propositions. His purpose of discussing principles in such a way as to bring geologists and geographers into substantial agreement, as interpreters of the features that indicate change of level is a distinct advance in the method of treating the subject.

Professor Johnson holds that a shore profile, a term that in his nomenclature embraces the shore proper, the shore face, offshore, and coast, is early established, whence there is a constant loss of debris with consequent motion of the shore line landward. This movement is attributed to continuous wave action, which of itself is declared sufficient to reduce irregular land areas to a plane or peneplane of marine-denudation. Simultaneously with wave action, the work of fluvial and wind action goes on from the land, but the effects, usually small in comparison, do not disturb the general cycle of shore development, though they may be sufficient in amount temporarily to disarrange materially the balance of operating forces and lead to a wrong interpretation on the part of observers. A very general view, which is here combated, represents the extent of wave action as extremely limited—because the force of the waves is held to be exhausted on the beach it has carved. If this view be correct, a marine cliff can be pushed inland by the waves, for only a short distance, and will remain unchanged in position unless subsidence of the land mass deepens the water and permits the waves further to erode the base of the cliff. Wave erosion has indeed been held as a proof, or at least as an indication, of land sinking. As a supporter of the contrary view, the author maintains that marine planation is possible without coastal subsidence, and that if the land stands long enough, that is given practically infinite time, any land area must eventually be worn away by the waves. Naturally many facts, or examples, are quoted and examined in support of this theory, and plenty of evidence is adduced, but the difficulty is to hold all the threads of the argument, giving to each its dué cogency, and to draw a conclusion that reconciles all. Moreover, we have an uneasy feeling that the cross-examination has not been conducted with rigour, and that we are the victims of special pleading. But everyone will admit the charm with which the author puts his case, and the industry displayed in the collection of material by which it is supported.

The development of the shore line, whether by submergence or emergence is of particular interest, and the formation of beaches, spits, bars, tombolos, forelands and deltas is not only clearly explained, but the wealth of illustration collected from natural features, hydrographic surveys and working models is of great use in following the author's explanations. All the generic forms are regarded as characteristic of young shore lines of submergence, but no attempt has been made to take into account the successive stages of these forms. In many cases such a step would be premature, for much is at present obscure. Their origin is however discussed with some fullness, and though the problem cannot be regarded as settled very good reasons are given for concluding that the influence of wind-formed waves is a more potent factor in their production than that of tidal or oceanic currents. With regard to the formation of offshore bars, there can be very little doubt but that the author is right in concluding that their origin must be sought in the action of waves breaking

up the sea floor, removing the disintegrated materials and heaping them up in ridges parallel to the shore. Longshore currents carrying shore drift meeting with the obstruction, deposit some of their load and form a contributory cause. The relative importance of each factor, and the time at which either operation is most effective, are points not susceptible of demonstration and must vary according to local circumstances. But in spite of some uncertainty and of some apparently decisive observations, there is no reason to treat the existence of offshore bars as presumptive evidence of coastal subsidence.

The last chapter dealing with some features such as beach-cusps, ripple marks, sand dunes, &c., though their influence on shore building is negligible, will be read with great interest, for these are phenomena that live in popular memory. Beach cusps is the term applied to the collection of gravel and coarse cobblestones, occasionally seen, heaped together at comparatively regularly-spaced ridges, which trend at right angles to the sea margin and taper out to a point near the water's edge. How these ridges were formed, what are the conditions favourable to their formation, and similar questions connected with their origin, have engaged the attention of many enquirers, how many we had no idea till reading the author's criticisms of the various theories that have been proposed to explain their appearance. None of the suggestions are found quite satisfactory, and greatly daring, Professor Johnson proposes a theory of his own, which probably will prove equally unacceptable to later writers. Similarly with ripple marks, a phenomena so familiar that it is difficult to believe that anything recondite can be hidden under their well-known forms, yet these have been the subject of many investigations, and various theories are more or less in favour. The literature of this subject is very extended, but the last word has not yet been said by any means. The author contrives to give a fresh turn to a well-worn topic by calling attention to the value these marks, preserved in a fossil state, may possibly have for the geologist, who perceives in them the means of determining the origin and structure of sedimentary rocks. Lastly, the subject of sand dunes is approached, but as these may be regarded as only indirectly related to shore processes they are passed rapidly by. One would have liked to have heard more of their migration and invasion of fertile tracts, and of the influence of vegetation in delaying their progress. Apparently, this impediment is nature's own method of restraint, with which man has wantonly interfered, and for which he has to pay the penalty. Some authors have seen in the growth and movement of sand dunes an indication of variation of level, but in opposition to this view it might equally be discussed whether their accumulation is not of modern origin. It has been remarked that sand dunes are not mentioned by ancient geographers, and in the old languages of the countries where these dunes are now encountered, no specific word is found to describe them. But the author has examined so many topics and discussed them so thoroughly, that it is quite unnecessary to drag in something which he has thought to be foreign to his purpose.

BOOKS RECEIVED.

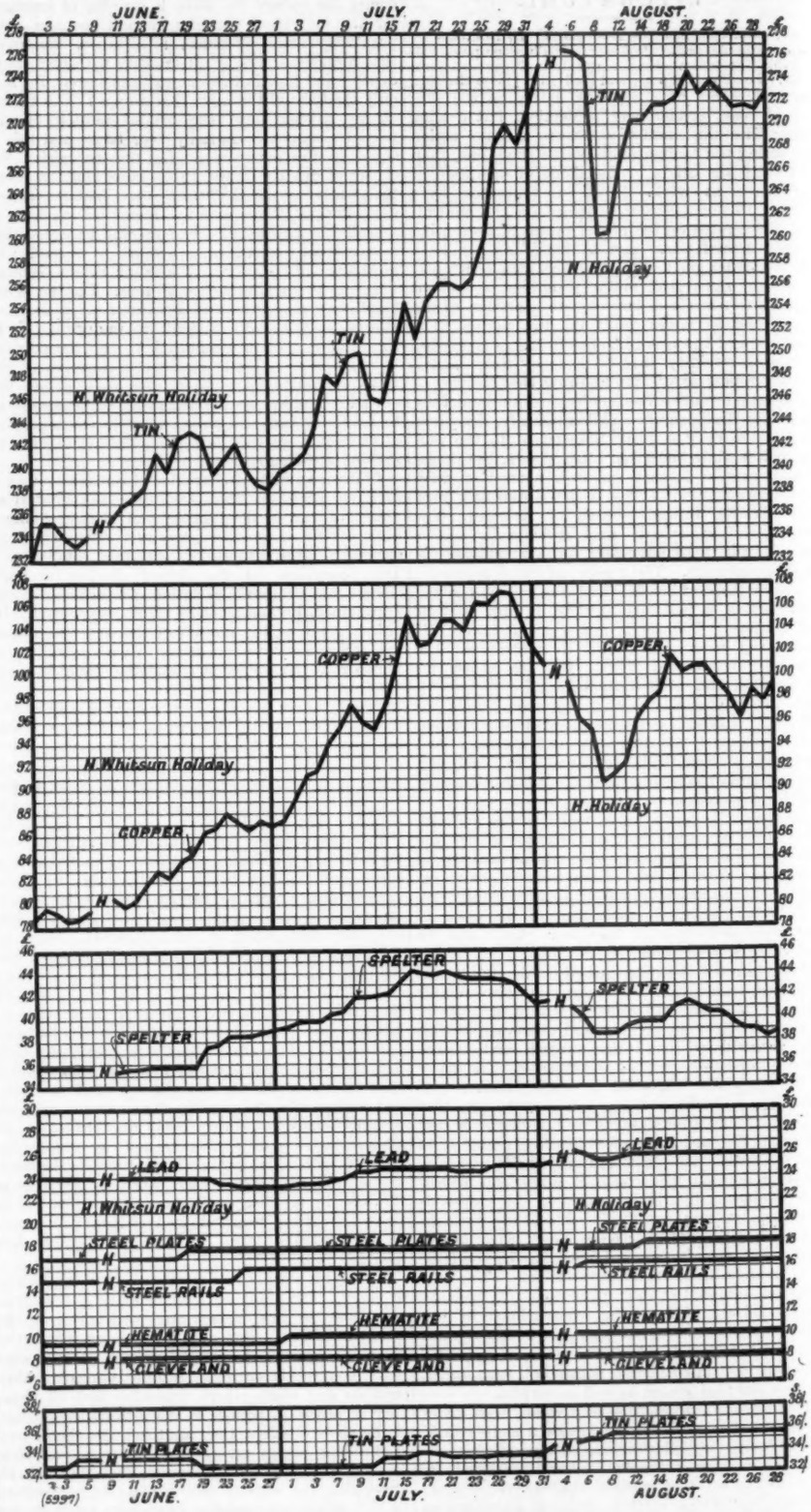
Elements of Wood Ship Construction. By W. H. Curtis. London: Hill Publishing Co., Limited.

The Iron and Steel Industry of the United Kingdom under War Conditions. A Record of the Work of the Iron and Steel Production Department of the Ministry of Munitions. By F. H. Hatch, Ph.D. Privately printed for Sir John Hunter, K.B.E., by Harrison and Sons, London.

Chemistry and Manufacture of Hydrogen. By P. Litherland Teed, A.R.S.M., Major, R.A.F. London: Edward Arnold. [Price 10s. 6d. net.]

James Watt: Date of his Death.—In the note on the James Watt Centenary and also in the memoir of Watt published in our issue of August 22, the date of Watt's death was, by an oversight, given as August 19. Used by both Muirhead and Smiles, this date was long regarded as the correct one, although the inscription on Chantrey's statue in Handsworth Church gives the 25th. Arago in his Eloge referred to August 25 as also does Bramwell in the Dictionary of National Biography, though without pointing out the error in the biographies of Muirhead and Smiles. In connection with the Centenary celebrations, the committee enquired closely into the question with the result that there seems little doubt that Watt died on August 25, and not August 19.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.



Note.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for "fine foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig iron. The prices given, in the case of steel plates, are for ship, bridge, and tank qualities, and those for steel rails are for heavy sections. The pig iron prices are for East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of tin-plates is per box of I.C. cokes free on board at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

GRAPHIC CHARTS FOR PETROLEUM BORE-HOLES.

By T. SINGTON.

Now that no less than five groups of petroleum bore-holes in Great Britain have been decided on, two of which are actually in progress, the system of daily record, by means of graphic charts, of the progress made, as well as of the accidents, water eruption and other difficulties incidental to petroleum search which cause delay, may be both interesting and opportune. This chart system has been introduced into the Californian oilfields, the second largest petroleum-producing area in the United States, with a total output this century of well over a thousand million barrels, of 42 gallons each, equal to an annual average of 53,700,000 barrels. Such an output from our own boreholes would at once not only put an end to our petroleum imports, it would convert this country into a petroleum exporter. These charts have been found to be of extreme use, really when once used indispensable, as they give the progress made and the results obtained at a glance. In the case of our own British petroleum hunt there would be obviously one chart for each of our five groups of boreholes: the seven in Derbyshire; the three in Nottinghamshire; the two in Staffordshire; the two in Midlothian; and another for those in the South Wales coalfield, the number of boreholes in which has not yet been published. The charts can be made for any depth of borehole and for any length of time, by the use of paper in a roll or in book form. To the manager or field superintendent of an oil company, graphic charts showing the progress of drilling work and of production need only a trial to demonstrate their utility and practicability. The expert and the average business man can acquire at almost a glance all essential details, which the usual typewritten records can furnish only after considerable expenditure of time and trouble. Oddly enough this chart system is due to the war, as it was introduced and elaborated in the Canadian army and then transferred fully developed into the petroleum industry. A Canadian officer, Mr. Matier, after active service in France, was invalided back to Canada in 1915 and attached to the Canadian Divisional Staff as staff chart-maker, with suitable rank.

In the course of time he prepared a vast number of charts by which the progress of efficiency of every battalion could be recorded from its recruiting stage to the veteran stage; age, medical condition, and so on, were shown by the system; percentages of trained men in musketry, bayonet fighting, reliability for front attack and all other necessary information, which formerly had to be obtained by long search through War Office returns. To change this system from men to petroleum was an easy and obvious step, and it has now been taken up as eagerly by the oil industry as it formerly was by the military authorities. The field department of the great Orcutt Oil Company is now supplied with charts recording every detail of drilling and production. It is only a question of time for it to spread over the whole of the United States. To quote the well-known Californian oil bulletin on graphic charts and their range of adaptability: In the analysis of a lease there are standards of comparison for both actual figures and percentages of gross oil, clean oil, water in suspension, free water and number of wells. These are compared for each month with the average month of the past year, showing the average production of each well in oil and water per day and per average year-day. Every aspect of the lease is brought out, its trend ascertained, the downward ratio of exhaustion, the number of barrels needed to keep it up to its average, thus giving a superintendent an idea of how much new work he must do to keep up this average, or better it; of course, relying on an average new well production and modifying this by the known rate of each new well. For petroleum purposes three sets of charts have been suggested: the first recording and detailing the track of drilling operations, the one illustrated; a second one recording the individual graphic well log; and another showing a year's production chart of a lease with the rise and fall and yearly average, worked out to show the trend of the lease.

The chart or diagram illustrated might apply to any British or foreign boreholes, it does not represent any special district; but it would obviously be desirable for each area to have its own chart; thus it would be inconvenient to have the Staffordshire and Nottinghamshire boreholes on the same sheet. Should there be a considerable number of boreholes in one county or district, two or more charts would be desirable to prevent overcrowding. The seven boreholes in Derbyshire would probably be the extreme limit for one chart. The specimen chart has only been carried down to 2,500 ft., but for actual work there is no limit, it might be fixed at 4,000 ft., the proposed depth of the boreholes in England, or 6,000 ft., the limit intended for Scotland; on the other hand, for shallow working it might be 500 ft. or 1,000 ft. For depth the chart is ruled off in equal spaces, each space representing 100 ft.; for time the chart is ruled off into, say, 1 in. spaces, from left to right, each space representing one day. A differently drawn line, or a different colour, could distinguish each borehole; the spaces from left to right are numbered from 1 to, say, 31 or 30 for each month; the depth in feet drilled every day is marked on the chart for each borehole and the broken or differently coloured lines are continued from left to right as shown on the illustrated chart, forming a visible unbroken record. The day's events, if any, are written out in the spaces for each borehole, thus: Drill pipe twisted off; bailer lost; shut down steam; coal supply run out; repairing boiler and so on; generally the fewer the records, the greater the progress. On the chart illustrated the No. 1 borehole was commenced on January 2, and passed successively through new red sandstone, Permian formation and portion of the coal-bearing rocks, the bailer was lost, fished for and recovered, and a day was lost pumping out water. The points at which the different formations are entered are noted on the chart, as well as the day and the depth when oil production was commenced. Should the casing collapse re-drilling at a higher level becomes necessary, as shown on one of the boreholes. A stoppage of the coal supply causes a complete stoppage of the work. When a borehole reaches the producing stage, the number of barrels of oil pumped per day is entered on the chart.

The convenience of these charts depends on the ease with which progress in different boreholes can be seen at a glance and compared; the time lost due to accidents, cementing and so on; reference to the data of former months or years can be rapidly made. What was being done at any borehole on a certain date; the formations passed through, the quantities of casing required can be ascertained forthwith. Each chart, in the form of a roll, could cover any desired period of time in the most compact form possible.

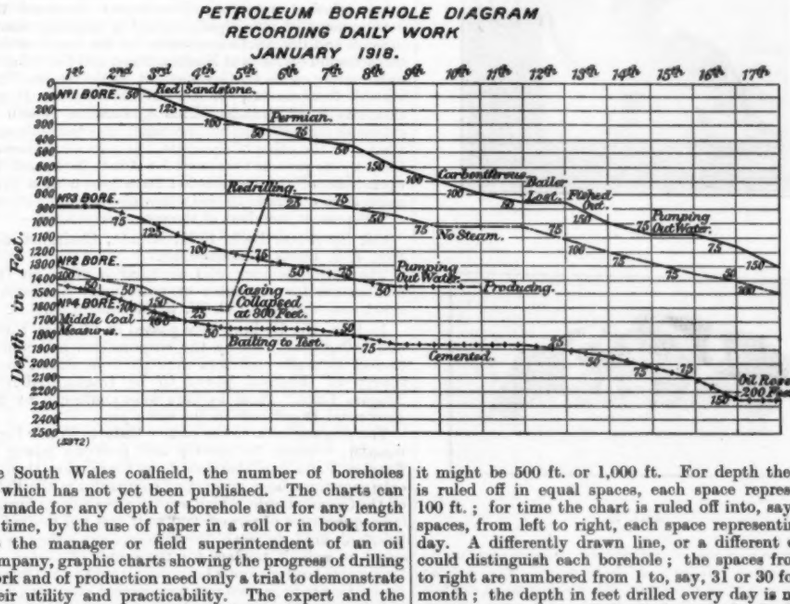
Another form of chart in use in the Californian oil-producing districts gives a graphic illustration of each borehole; its length from top to bottom, say, for the Derbyshire boreholes, would be 4 ft. and its width 2 ft., the whole area divided by thick lines into squares of 1 in.; whilst each square inch is divided by fainter lines into 100 small squares. Each of these small squares from top to bottom represents 10 ft. of depth of the borehole. Each borehole may be three of these small squares in width from left to right, drawn in by a thick black ink line, and a width of 3 in. may be allowed for each borehole with its attendant notes, figures and so on. The formations passed through—new red sandstone, limestone, coal measure rocks and others—are indicated by different colours. The depths are figured every inch—100 ft., 200 ft., 300 ft., and so on; the tenth inch completes 1,000 ft.; the twentieth inch 2,000 ft., and the fortieth inch 4,000 ft., the depth, say, of the Derbyshire and Staffordshire boreholes.

At the top are the name and locality of the borehole, the height above sea-level, the names of the drillers, the date when the boring commenced. The diameters of the casings used for the borehole are also placed at the top: 17 in., 12¼ in., 10 in., 8¼ in., 6⅝ in., or any others. These pipes may be indicated by coloured lines alongside the borehole as far down as each diameter extends and the depth where each end is figured, thus the 12¼-in. casing pipes may extend downward 365 ft., and the 10-in. pipe 2,010 ft.

The top of the 8¼-in. casing pipe may commence at a depth of 1,920 ft., and it may extend downwards for a depth of, say, 1,470 ft. The different varieties of rock passed through besides being indicated by colour are noted in terms on the right side of the borehole; the depth at which oil is found (if any) and the date, also the number of barrels raised per day.

When the boreholes pass through water containing rocks, the iron casing has to be cemented. Some notes from the Californian petroleum-producing districts may foreshadow what may be expected here should Great Britain become, as many expect, a great oil-producing country. Everything in America appears to be on a vast scale, the sedimentary rocks, along the Pacific Coast bordering the petroliverous areas are no less than 70,000 ft., equal to 13 miles in thickness, representing a lapse of time and a wear and tear of former mountain ranges practically inconceivable. The petroleums obtained at different levels pierced by the same borehole differ in the most remarkable manner: One bed of oil may contain salt water to the extent of even 90 per cent., whilst a lower bed may contain less than 1 per cent. Prolonged experience gained from a large number of boreholes during many years indicates a definite tendency towards exhaustion; a broad rule has been formulated based on the production figures of over 400 wells and extending over a period of fourteen years, to the effect that there is a diminishing output of clean oil amounting to 7 per cent. per annum; but each well has its own peculiarities and the output may be very erratic! Thus one well in an important Californian oil district produced an average of 10,000 barrels of oil per day for the first 30 days after the completion of the drilling; whilst a neighbouring well only 50 ft. away yielded nothing beyond muddy water. An earth tremor occurred one night, resulting in the collapse of the casing of the first of these two wells, when this had been made good the yield of the well was limited to water, and only traces of oil are found in the water even up to the present time. Coal-mining enables the expert to examine the coal and the rocks above and below *in situ*, and our accumulated knowledge is very extensive; but as regards oil our knowledge is limited to the crushed matter, brought to the surface by the baler in the form of mud, we therefore know very little of the conditions and surroundings of oil accumulations. We cannot, therefore, account for phenomena such as those mentioned above.

On the other hand, numerous other wells which before the tremor were very poor producers, were found the following morning with the oil coming over the casing head. The number of flowing wells in the Californian oil areas is limited, and the flow is not maintained for a long period, possibly that may be due to the large number of boreholes and their being placed too near each other; pumping is therefore very generally resorted to from depths ranging from 1,600 ft. down to 4,500 ft. No rule can be formulated as to the time required to sink a borehole, experience is no guide; a well 4,000 ft. in depth may be drilled in eight months, but should accidents occur it may take five years. The accidents boreholes are liable to are most varied, wire cables cut the casing, or get stranded; tools fall over on their side in an open hole below the bottom of the casing, to fish them out is probably the most difficult task which can confront the drillers. Some wells have been drilling for four years, and are only down to 3,500 ft. It follows from this experience that we have been very fortunate in our Derbyshire boreholes, the first was started about the middle of last October, and already two of them are lower than the 3,000-ft. level; by the time this is in type there may be three boreholes out of seven lower than 3,000 ft. In many Californian oil wells, when drillers approach the oil zone, the casing



collapses, say, at the 1,500-ft. level, and then the whole well has to be drilled again with the old casing in the way adding to the difficulty. It is drilled past, if possible, or driven ahead until it is side tracked; alternatively the well may be shot with gelatine and the old casing blown into the sides of the well. In the case of one well, which had been pumping about 50 barrels per day for many years the casing unfortunately slivered at a depth of 2,500 ft.; it was decided to try the effect of gelatine, and 25 lb. were put down to blow the casing out of the way. The result was astounding, the explosion was immediately followed by a rush of oil and gas over the derrick head, and 15,000 barrels flowed the first day, about the middle of June. Such an outburst would soon fill the 200,000-gallon tank erected at Hardstoft, in Derbyshire, in fact, a whole series of them. Attention was drawn above to the tendency towards exhaustion manifested by oil wells in America; the following statistics of the petroleum output in barrels of 42 gallons each, in several States will make that clear :—

Year.	Pennsylvania and New York.	Ohio and Indiana.	Kentucky and Tennessee.
1900	14,559,000	27,237,000	16,225,000
1902	13,183,000	28,495,000	13,698,000
1904	12,239,000	30,215,000	13,642,000
1906	11,345,000	21,500,000	11,750,000
1908	11,094,000	11,095,000	10,292,000
1910	8,547,000	12,286,000	11,747,000
1912	8,712,000	9,939,000	12,613,000
1914	8,536,000	8,994,000	10,466,000
1916	6,980,000	7,905,000	10,160,000

Other States are increasing their output very rapidly, as the following figures indicate :—

Year.	Kansas and Oklahoma.	Colorado and Wyoming.	Texas and Louisiana.
1905	11,854,000	500,000	40,572,000
1910	52,642,000	347,000	17,213,000
1916	119,233,000	6,837,000	44,037,000

California, in 1900, produced 4,099,000 barrels, and in 1916 increased the output to 91,822,000 barrels.

RIVER DISCHARGE.

By HERBERT CHATLEY, D.Sc.(Eng.), M.Inst.C.E.I.

IN the course of investigations made for the Whangpoo Conservancy Board during the past three years as to the regulation of the Whangpoo and Yangtze rivers, the writer has had an exceptional opportunity to compare the various discharge formulæ with actual results on large streams with irregular flow. Although this subject has been discussed almost *ad nauseam*, the results obtained appear so important that the writer ventures to think they are worth publishing.

In the first place, it appears from the observations that all the standard formulæ have no applicability whatever to natural sinuous and irregularly sectioned streams because of the "dissipation" losses at the bends and changes of section. The energy so lost may easily amount to as much as the friction head obtained from formulæ.

Secondly, it was found that in fairly straight and uniformly sectioned reaches when the flow is steady the exponential form :

$$V = C \cdot R^{0\cdot7} \cdot I^{0\cdot5} \quad . \quad . \quad . \quad 1)$$

gives consistent results, I being the local slope or tangent to the water surface at the measuring section.

Thirdly, it was found that when the flow was unsteady in regular channels, the velocity followed a form :

$$V = C\, R^{0\cdot7} \left(I - \frac{a}{g}\right)^{0\cdot5} \quad . \quad . \quad . \quad (2)$$

where a is the acceleration. In other words, the effective slope is equal to the algebraic difference between the actual slope and an "acceleration" slope determined by the ratio of the actual mean acceleration of the water to the gravitational acceleration.

It appears then that :—

1. No advantages are obtained by using the complex Bazin, Ganguillet and Kutter, Hessle or similar formulæ, as the unavoidable errors of measurement and the irregularities which occur in even a very short length of a natural river, cause variations greater than the differences between these formulæ so that the mathematical advantages of the exponential form render it the most suitable.

2. In long reaches the energy dissipated in the creation of lateral induced currents and eddies at bends and changes of sectional form may be as great as the bed friction, so that formulæ are of no value except for short straight reaches with fairly uniform cross section.

3. The rise or fall of the "stage" introduces an appreciable "acceleration slope" which must be allowed for in the formulæ. One of the writer's former colleagues, Mr. A. Frey Samsioe, initiated a graphical analysis which led to the discovery of the "acceleration slope."

THE "AUTOSET" CLAMP.

THE accompanying illustrations show two sizes of a handy little appliance for workshop use, which is manufactured by the Autoset Clamp Company, Limited, of Caxton House, Great Charles-street, Birmingham. It is a self-adjusting clamp, or dog, for fixing work to the tables of machine tools, and its special feature is that its use avoids the necessity for the collection of miscellaneous packing pieces employed with clamps of the usual forms. The illustration Fig. 1 shows the "Autoset" clamp in use, and is practically self-explanatory. As will be seen, the clamp itself is slotted longitudinally and provided with a series of

FIG. 1.

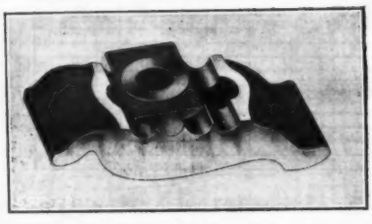


FIG. 2.

transverse grooves, of semicircular cross section, on its upper surface. In one of these grooves fits a bead formed on a washer, and on this washer bears the nut of the bolt used for fixing the work. The arrangement, of course, allows the clamp to set itself at a considerable angle with the bolt, so that, although the latter remains quite vertical, one end of the clamp can rest on the machine table while the other end bears on the top of the work. As will be seen the clamp illustrated in Fig. 1 has three grooves, which enable it to deal with work ranging from $\frac{3}{8}$ in. to $1\frac{1}{2}$ in. in thickness, while that shown in Fig. 2 has four grooves and can be used for work up to $2\frac{3}{4}$ in. thick. The clamps are made in other sizes, and in two other designs. In one of the latter the upper surface of the clamp forms part of a cylindrical surface and the washer is made to fit this, while in the other design the bolt passes through a rectangular block pivoted inside a slot in the clamp. In both cases the clamp is free to set itself at an angle with the bolt, but the latter arrangement has the advantage that there are no separate parts to get lost.

Messrs. R. H. Lash, Limited, of 29–31, Portugal-street, Kingsway, London, W.C.2, are the sole wholesale concessionaires for these clamps for the United Kingdom and abroad.

THE ONTARIO HYDRO-ELECTRIC POWER SYSTEM.

THE Ontario hydro-electric power system in Canada is one of the most important enterprises of its kind on the North American continent. It develops over 200,000 h.p., which it sells to the people of Ontario, chiefly in the south-west portion of it, and is rapidly extending its operations. The capital investment under the Commission's jurisdiction is over 54,000,000 dols., while the investment of muncipalities in connection with the system equal another 21,000,000 dols. It is expected that by the end of 1921 the total investment will be 110,000,000 dols.

As indicating the value of the commission's work to Ontario, it may be said that were the power now being supplied to be obtained from coal, even in fairly large, modern, generating stations, over 2,000,000 tons would be required and 4,000,000 in industrial plants, the value of which would be approximately from 10,000,000 dols. to 20,000,000 dols., and, as Ontario has no coal, this money would have to go out of the province.

About 20 years ago, at a time when the art of generating and transmitting electric energy was beginning to make rapid strides, it was felt by the manufacturers of South-Western Ontario that the water powers of Niagara Fall might be utilised to supply energy to places at a considerable distance from the Falls themselves. Several public meetings were held and an unsuccessful attempt was made in 1900, by the City of Toronto, to obtain legislation enabling it to generate power at Niagara and transmit it to the City. The idea of making use of Niagara power was, however, taking hold of people's minds in other places, and in 1903 the Provincial Government authorised the appointment, by the municipalities, of a commission to thoroughly investigate the whole power situation.

This commission, which bore the name "The Ontario Power Commission," made a very full report in 1906, in which the availability and costs of power from various primary sources, viz., coal, gas, oil and water were considered in detail together with the prospective markets, costs of development of Niagara Power and other relevant matters. This report favoured the development of municipally owned generating, transmission and distribution systems for the towns within transmission distance of Niagara Falls, and following its publication came the creation in 1906, by the Provincial Government, of the Hydro-Electric Power Commission of Ontario. This commission is still in existence and although its personnel has changed somewhat, yet the office of chairman has been continuously filled by its present occupant, Sir Adam Beck, and the operations of the commission have grown in a little more than a decade to their present vast proportions.

The present members of the commission are :—

Col. Sir Adam Beck, K.B., K.L.D., Chairman, and Hon. I. B. Lucas, Commissioner.

The third member who occupied a place on this commission for a number of years until his death a short time ago, was Col. W. K. McNaught, C.M.G.

In 1908, the By-laws were passed in 13 cities, towns and villages authorising the corporations or councils thereof to make contracts with the commission for a supply of electrical power to be transmitted from Niagara Falls. These by-laws were confirmed by the Provincial Legislature in the same year.

The original idea of the earlier Ontario Power Commission, actually to develop and generate power at Niagara Falls was abandoned, as there were then in existence three large generating companies at the Falls, on the Canadian side, which were in a position to furnish large quantities of power, and as it was not desired to interfere unfairly with these companies, they were asked to submit tenders for the supply of power. A favourable tender having been submitted by the Ontario Power Company, a contract was entered into with this company for 100,000 h.p., the first 25,000 h.p. to cost 9·40 dols. per horse power year, and the remainder 9·00 dols. per horse power year, for 24 hour power; this provided that the power should be three phase alternating, at 12,000 volts, and that it should be delivered in blocks commencing with 8,000 h.p., increasing as the commission should require in blocks of 1,000 h.p., until the maximum of 100,000 h.p., should be reached. The commission undertook not to obtain power from any other source until the full amount of power contracted for had been absorbed.

The action of the commission in making a contract for what at that time, appeared to be so large an amount of power, was very severely criticised on the ground that it would be many years before the entire contract was utilised. In order to show the value of this criticism it is worth while noting here that the commission exhausted this contract in five years from the date when power was taken in 1910, and that in 1918 the power obtained from Niagara Falls alone was over 151,000 h.p., while altogether, from the various systems owned by the commission, there were supplied during the winter (1918–1919) over 198,000 h.p.

Although the commission started its operations by merely transmitting power from Niagara Falls and selling it in bulk to the municipalities it was found desirable, as time went on, to take over (this has been done by purchase) several generating systems in various parts of the province, while in other cases arrangements were made to purchase power and transmit it to surrounding districts just as was originally done at Niagara.

The commission now owns and operates a dozen systems in other parts of the province. In December, 1917, as many as 225 municipalities were supplied with power.

In connection with the Port Arthur system work has been commenced on a new development on the Nipigon

River which will have an ultimate capacity of 75,000 h.p., and there are three other sites which can give about another 100,000 h.p. in this district when required. In the Central Ontario district plans are being prepared for the development of 10,000 h.p., at Ranney's Falls on the Trent River. Eugenia and Wasdell's Falls are power sites which have been developed and equipped by the commission; in the other cases power was already developed, the commission merely purchasing and taking over existing plants.

The majority of the stock of the Ontario Power Company has been purchased, and this plant is now operated by the commission under agreement, the total generating capacity being 160,000 h.p., to which another 50,000 h.p. will be added shortly when a third pipe line now in course of construction, is completed.

The Niagara system on account of its importance requires separate mention. Five years from the time when the contract for 100,000 h.p. was made with the Ontario Power Company at Niagara Falls the whole of this power was being used by the commission, and a contract with the Canadian Niagara Power Company for 50,000 h.p. was made, and at the present time over 150,000 h.p. is the amount being transmitted from the Falls over the commission's power lines.

When it was evident that the full amount of the 100,000 h.p. contract which the commission had with the Ontario Power Company would be entirely absorbed, it became necessary to ascertain whence a further supply of power might be obtained. As a result of careful investigation of the various schemes which had been proposed from time to time by experts, for development at Niagara Falls, and of surveys made by the commission's own engineers it was decided that the best plan would be for the commission to have its own development works and generate power on a large scale.

The proposed scheme was laid before the Provincial Government in 1913, and powers enabling the commission to go ahead with the work were obtained in 1916, and in 1917 work was commenced on what is known as the Queenston-Chippawa Development. This involves the construction of a canal about 12¼ miles long, run from the point above the Falls where the Welland River discharges into the Niagara River down to a location near Queenston where the power station will be.

The existing companies at Niagara utilise the head at the Falls, obtaining there about 150 ft. head. In the section between the foot of the Falls and Queenston, there is, however, a further drop in the level of the river of about the same amount as at the Falls. Thus, the commission, by the scheme which is now in hand, will obtain a net working head of 305 ft., so that from the same water over 100 per cent. additional power will be obtainable.

The initial equipment to be installed in the generating station near Queenston will comprise four of the largest hudraulic turbines ever built, each of these have a capacity of 52,500 h.p., four electric generators of 45,000 k.v.a. capacity will be coupled thereto. Units of 100,000 h.p. each are contemplated for later developments. The present canal will be large enough to enable 300,000 h.p. to be developed, and enough land has been purchased to enable two additional canals to be constructed in the future, so that the total capacity of the plant may be 1,000,000 h.p. if, as is fully anticipated, the demand for such an amount of power should arise in the not distant future, and if arrangements can be made for the diversion of the requisite amount of water from the Niagara River.

Four and one-quarter miles of the canal will consist of the present Welland River, widened and deepened, and reversed in the direction of its flow, in the section between the Niagara River and the excavated portion of the canal, the remaining 8¼ miles will be excavated. The Hydraulic Department, in addition to undertaking the design of all the hydraulic features of such work as this, has been engaged for the past six years in taking records of stream flow, and has established 57 gauging stations which are under regular observation, in 45 different rivers covering a drainage area of about 47,000 square miles.

ON THE RAPID SEASONING OF JARRAH.*

By ALFRED TOMLINSON, M.Sc., Assoc.M.Inst.C.E., M.C.I.

(*Concluded from page* 289.)

Operation of the Kiln.—At the commencement of operations the timber must be heated through before any drying takes place. It is thus usual to steam the timber at a temperature of about 120 deg. F. for a few hours (see Appendix I). The steaming is also useful in removing any initial or residual case-hardening before beginning drying. Briefly, the minimum percentage humidity of the circulating air is governed by the percentage moisture content of the stacked timber (see Appendix I). From green to fibre saturation point (30 per cent.) the humidity must be high, from 85 per cent. to 75 per cent., never less, while it appears the maximum kiln temperature, with jarrah, is about 115 deg. F., say (see Appendix I). After this point has been passed, the percentage humidity may be gradually decreased until it reaches about 40 per cent. at end of drying operation, the temperature also during this period being gradually increased, reaching a maximum of 140 deg. F., say. The percentage moisture content of the stack must evidently be obtained from time to time. Accordingly, sample boards are placed in the kiln and these are weighed, from time to time, and their percentage moisture content determined (see Appendix III). It is also necessary to take, from time to time, prong sections of material in the kiln in order to control the rapidity of the drying and case-hardening. If excessive case-hardening is taking place it may be quickly removed by restoring surface plasticity, that is by subjecting the timber to a warm saturated atmosphere, usually steam, for a few hours. The behaviour of sections of 1-in. boards pronged during the various stages of the drying is shown in Fig. 8, and needs no further explanation. Conversely, these sections may clearly be used to roughly indicate the moisture content. The timber may be considered thoroughly kiln dried if moisture content is about 8 per cent. Provisional instructions for drying jarrah are given in Appendix III.

Fig.8. BEHAVIOUR OF SECTIONS IMMEDIATELY AFTER PRONGING DURING THE VARIOUS DRYING STAGES.

The Per Cent Moisture Contents are Approximate.

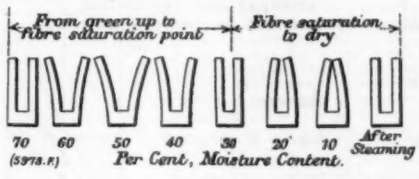

From green up to fibre saturation point
Fibre saturation to dry
70 60 50 40 30 20 10 After Steaming
(5978.F)
Per Cent. Moisture Content.

Fig.9. TYPICAL DRYING CURVES.

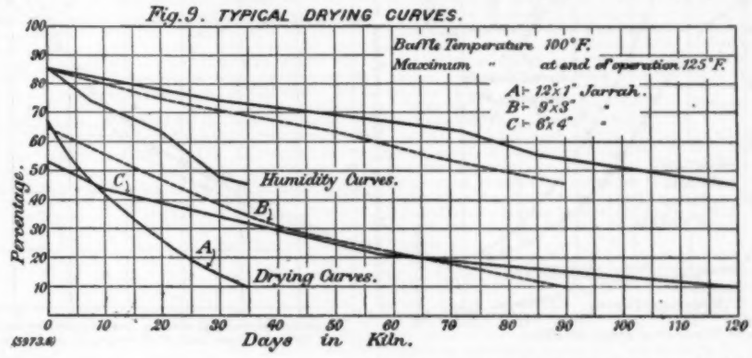
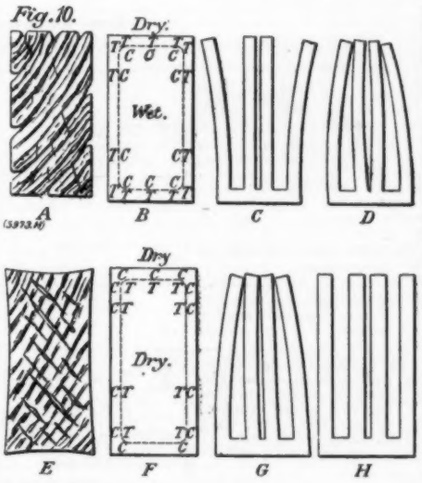


Fig.10.



Outside Checking.—

(A) Outside checking (permanent) due to rapid surface drying, and the strength of the wood being insufficient to resist the internal stresses.

(B) Outer shell, T, drier than interior, C. T = Tension, C = Compression.

(C) If disc (B) be pronged, by 5 saw cuts, it will at once spring into this shape.

(D) If prong (C) be dried thoroughly it will assume permanently the form (D).

Inside Checking.—

(E) Internal checking or honeycombing (permanent), after wood has more or less completely dried, due to strength of wood being insufficient to resist the internal stresses.

(F) Outer shell, C, below the fibre saturation point, and "set." Permanent stresses. T = Tension, C = Compression.

(G) If disc (F) be pronged, by 5 saw cuts, it will bind the saw and immediately spring into this shape.

(H) Disc pronged and without casehardening. If (F) be steamed and stresses neutralised or removed, thereby a pronged disc will assume the form (H). If steamed too much a pronged disc will spring into the shape (C).

quickly removed by restoring surface plasticity, that is by subjecting the timber to a warm saturated atmosphere, usually steam, for a few hours. The behaviour of sections of 1-in. boards pronged during the various stages of the drying is shown in Fig. 8, and needs no further explanation. Conversely, these sections may clearly be used to roughly indicate the moisture content. The timber may be considered thoroughly kiln dried if moisture content is about 8 per cent. Provisional instructions for drying jarrah are given in Appendix III.

Additional Difficulties in Operation.—Difficulties in operation, apart from those already mentioned, are due to the fact that the stacked material, which is being evenly dried in the kiln, has naturally considerable variations in (i) moisture content, (ii) density. Thus some pieces may contain 75 per cent. and others 40 per cent. moisture, while the density may vary between 37 lb. and 52 lb. per cubic foot when dry.* It appears to be necessary, in order to be on the safe side, to subject the "mixed" material to comparative mild drying conditions.

Results of Tests.—Fig. 11 shows the particulars, arranged graphically, of a typical kiln-drying operation. Fig. 9 shows drying curves, respectively, for 1 in., 3 in. and 4 in. thickness jarrah, which was uninjured in seasoning. Roughly, using the information now available, the rate of drying jarrah, from fairly green to 10 per cent. moisture content, without injury, and the conditions being mild, is as follows: ½-in. stuff, 7 days to 10 days; 1-in. stuff, 4 weeks to 5 weeks; 3-in. stuff, 3 months; 4-in. stuff, 4 months. It may also be noted that it appears to be desirable to kiln dry the jarrah as soon as possible after cutting, for end checking soon takes place in the air. This is contrary to American practice with hardwoods, which are air dried for six months, or over, before placing in kiln.

APPENDIX I.

Results of Experiments.—Investigations on the behaviour of jarrah in drying are by no means complete. Sufficient information, however, has been obtained for a rational understanding of the causes and prevention of injuries. The following physical properties of jarrah (which are more or less similar in other woods†) when drying have been established:—

1. (*a*) Shrinkage begins when green, with a moisture content of 70 per cent., say, and continues until dry. From green to the fibre-saturation point shrinking proceeds at an even rate, and afterwards at an increased uniform rate (about two-fold). It is believed that the contraction at first is due to a form of collapse of the cells, and afterwards to the "true" shrinkage of the cell walls. (See Appendix II.)

(*b*) The moisture content reckoned on dry weight is about 30 per cent. at the fibre saturation point. (See Appendix II.)

2. (*a*) Rate of transfusion of moisture through the wood is slow compared, say, with the softwoods.

(*b*) Moisture tends to transfuse from the hot towards the cold portion of the wood.

3. (*a*) Is plastic while hot and moist and becomes "set" in whatever shape it dries.

(*b*) Is excessively soft and plastic under moist conditions when temperature is as low as, say, 150 deg. F.

4. Shrinks less in a damp atmosphere, when dried rapidly than when dried slowly.

Injuries and Prevention in Seasoning.—From the foregoing facts the troubles and remedies in drying will be readily understood, some of which are dealt with below.

Cause of Checking.—Checking results from item 1 (*a*), that is, unequal shrinkage. In drying jarrah, the necessarily drier outer shell tends to shrink or contract more than the wet inner core. The latter prevents it from doing so, and this straining action sets up stresses, owing to differential drying. The outer shell is evidently in a state of tension and the interior in compression, as shown in Fig. 10, diagram B. If the contraction is comparatively great these resulting stresses will exceed the strength of the timber across the grain, which will be torn apart on the outside in checks, as in diagram A, and the material will be relieved of stress.

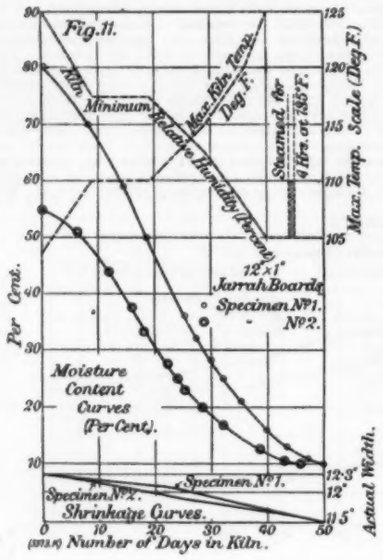
Cause of Case-hardening and its Evils.—Case-hardening results from items 1 (*a*) and (*b*), 3 (*a*), and 4, and occurs when the surface of the wood becomes "set" (*i.e.*, below the fibre saturation point) in a partially dry condition, while the interior is still wet. This condition is due to too rapid surface drying, *i.e.*, the evaporation from the

* Paper read before the Western Australia Institution of Engineers, at Perth, on May 14, 1919.

* See W.A. University Timber Tests, 1917.

† See "Kiln Drying of Lumber," by H. D. Tiermann.

surface exceeds the rate at which the water in the centre transfuses outwardly. If the interior of the case-hardened piece of wood dries further it tends to shrink, while the "set" condition of the surface, or outer shell, tends toprevent it from doing so. As a result of this, together with item 4, viz., "that the slower wood dries the greater the shrinkage," the strains, and consequently the stresses set up, are the reverse of those already considered. For now the outer shell is in compression and the interior in tension as shown in diagram F (Fig. 10). If these stresses exceed the strength of the timber, portions of the interior of the timber will rupture and splits will appear, as in diagram E. This internal checking is usually called honeycombing. It has been seen that excessive case-hardening ends in checking and honeycombing. Since disaster will take place in seasoning unless case-hardening is controlled, it is evidently a very important factor.



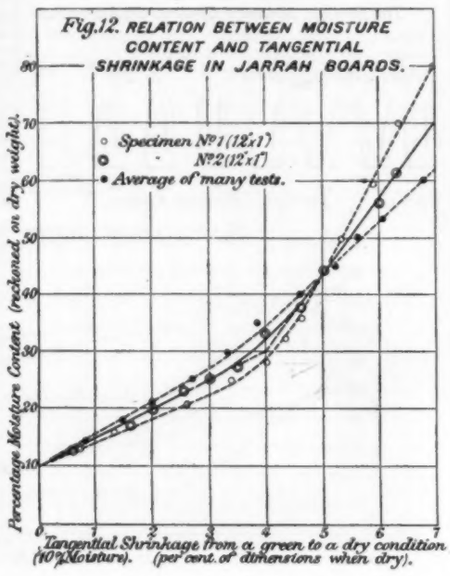
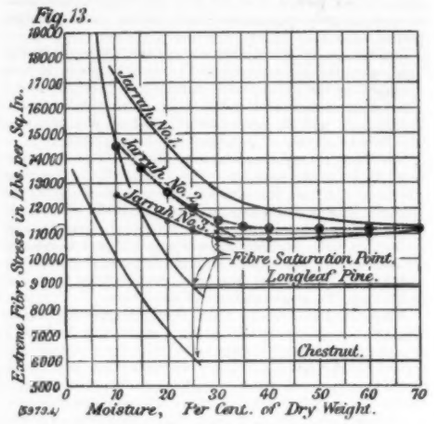


Fig.12. RELATION BETWEEN MOISTURE CONTENT AND TANGENTIAL SHRINKAGE IN JARRAH BOARDS.
Specimen No 1 (12"x1")
No 2 (12"x1")
Average of many tests.
Percentage Moisture Content (reckoned on dry weight).
Tangential Shrinkage from a green to a dry condition (per cent. of dimensions when dry).
(10% Moisture).



Fibre Saturation Point.—

No. 1. Taken from W A timber tests, Plate No. 3, size A. Strength calculated on actual section at breaking.

No. 2. Obtained from No. 1 by calculating the strength due to alteration in section modulus, on the probable cross section when green using shrinkage curves.

No. 3. Obtained from No. 1 by calculating the strength due to alteration in section modulus and density on the probable cross section when green using shrinkage curves.

Prong Tests for Case-hardening.—Simple tests, as under, may be used before the wood, of course, is permanently injured, for indicating the case-hardening if any. Discs, or narrow cross-sections, say 1 in. thickness, are sawed across the piece of wood to be tested. These are immediately slotted according to diagram H (Fig. 10) by running, if possible, five parallel saw cuts nearly through, and breaking away two of the tongues thus formed—namely, the second and fifth. If the prongs at once show no tendency to bend outwardly or spring inwardly, as in diagrams C or G, respectively, but remain normal, as at H, there is little or no case-hardening, for the material must be in an unstrained condition and thus free from shrinkage stresses. If the outer prongs at once bend outwardly, as in diagram C, then the outside is drier than the inside and the piece is in a first stage condition leading to case-hardening, with its tendency to check. If C is now dried in a warm room, the prongs will finally bend inwardly, and remain so permanently. The outer prongs will all spring inwardly, as in diagram G, if the outside has "set," that is, if in the final stage of case-hardening, with its tendency to honeycomb. In the above the stress diagrams B and F readily explain the action of the prongs.

Prevention of Checking.—Evidently, outside checking due to excessive surface drying may be prevented by properly adjusting the humidity of the air and so controlling the surface evaporation. It has been found that the moisture content of the wood determines, to some extent, the allowable or minimum safe working percentage humidity of the circulating air. Thus, if percentage moisture content of wood is high, the percentage humidity of the air must be high. Green or high moisture content jarrah can only be successfully dried at first in a damp atmosphere, say, 85 per cent. humidity. Again, with 1-in. boards during almost the whole of the drying operations it appears to be undesirable for the humidity to be less than 75 per cent. It should be noted that the rate of surface evaporation should not be controlled by reducing the air circulation, since a large circulation is needed at all times to supply the necessary heat.

Prevention of Case-hardening and Honeycombing.—Honeycombing, obviously, may be eliminated by preventing undue case-hardening. If case-hardened, the material would be in a stressed condition, as in diagram F (Fig. 10), and a little thought should suggest a means by which it may be removed. Clearly, if the hard outside shell were softened, the "outside set" and resulting strains (as in diagram F) would vanish and the piece relieved of stress. Experiments (item 3 (*b*)) showed that thoroughly moist warm air caused the wood to become soft and plastic, and thus remove case-hardening. In the kiln (Fig. 5, page 288), steam pipes D with perforations are provided to admit live steam, which will maintain a thoroughly wet atmosphere, and even with a comparatively low maximum temperature of 140 deg. F. the case-hardening will be entirely eliminated in a few hours, provided it has not gone to the extent of causing honeycombing.

Prong Tests for Removal of Case-hardening.—Case-hardening material when pronged, as explained before, will assume the form shown in diagram G (Fig. 10). If after steaming another pronged section of the material remains normal, as at H, the case-hardening has been eliminated and the exposure has been correct. If the steaming process has been carried on too far, a pronged section will take the form shown in diagram C.

Warping, Twisting or Cupping is due to internal stresses caused by unequal shrinkage. Case-hardening is one cause. It is often due to the warped direction of the grain of the wood, coupled with the fact that the shrinkage is different in different directions. "Curly grain" is very apt to warp, and an "interlocking grain" is even more effective. Another cause is through the expelling of moisture evenly from all parts in which it does not exist evenly. Of course, case-hardened boards (diagram F, Fig. 10), when sawed down the centre, so as to make two boards of half the original thickness, will cup, the original surface becoming convex. Articles then manufactured from case-hardened material are apt to warp and give trouble.

Prevention of Warping and Cupping.—In the drying kiln warping and twisting can be prevented to some extent by careful stacking or piling. The distance pieces or "strips" (Fig. 7, page 289) are placed at suitable intervals apart in the transverse direction. The weight of the superincumbent timber acting through these strips tends to prevent the twisting of individual boards. The cupping trouble is eliminated by arranging for the surfaces of a board to dry at an equal rate. Even air circulation in the kiln—sloping stacking and uniform thickness of strips—will ensure even drying of the two faces.

Temperatures for Drying.—Items 1 (*a*), 2 (*a*) and 3 (*b*) indicate clearly that comparatively low tempera-

FIBRE SATURATION POINT ANALYSIS.

b and d are dimensions of beam when dry (10 per cent. moisture content).

M = per cent. moisture content. S_{green} = maximum rupture bending stress when green (70 per cent.)

$\alpha = \frac{M-10}{500} : \beta = \frac{M-30}{1{,}333}$ S_M = ,, ,, ,, moisture content M.

PARTICULARS.	PERCENTAGE MOISTURE CONTENT.	
	M > 10 < 30	M > 30 < 70.
Probable dimensions at M, per cent. moisture	$b\,(1+\alpha$ $d\,(1+\alpha/2)$	$b\,(1+0.04+\beta)$ $d\,(1+0.04/2+\beta)$
Probable dimensions when green at, say, 70 per cent. moisture content		$b\,(1+0.07)$ $d\,(1+0.05)$
Ratio of probable rupture bending stress on section when green (70 per cent.) to actual stress on section at rupture (M per cent.) (*i.e.*, taking shrinkage into account) Stress, $S \propto 1 \div b\,d^2$	$\frac{S_{green}}{S_M} = \frac{b\,(1+\alpha)\,d^2\,(1+\alpha/2)^2}{b\,(1+0.07)\,d^2\,(1+0.05)^2}$ $= 1+\alpha+2\,\frac{\alpha}{2}-0.07$ -2×0.05, approx. $= 0.83+2\,\alpha$ or, $A = 0.83+\frac{2}{500}$ M–10)	$\frac{S_{green}}{S_M} = \frac{b\,(1+0.04+\beta)\,d^2\,(1+0.02+\beta)^2}{b\,(1+0.07)\,d^2\,(1+0.05)^2}$ $= 1+0.04+\beta+0.02\times2+\beta\times2$ $-0.07-0.05\times2$, approx. $= 0.91+3\,\beta$ or, $B = 0.91+\frac{3}{1{,}333}$ (M–30)
Ratio of probable density (apart from water) of green section (70 per cent.) to density of actual section at rupture (M per cent.) (*i.e.*, probably "strength" will vary directly as "density" Density. $D \propto 1 \div b\,d$	$\frac{D_{green}}{D_M} = \frac{b\,(1+\alpha)\,d\,(1+\alpha/2)}{b\,(1+0.07)\,d\,(1+0.05)}$ $= 1+\alpha+\frac{\alpha}{2}-0.07-0.05$ [approx. $= 0.88+\frac{3}{2}\,\alpha$ or, $K = 0.88+\frac{3}{1{,}000}$ (M–10)	$\frac{D_{green}}{D_M} = \frac{b\,(1+0.04+\beta)\,d\,(1+0.02+\beta)}{b\,(1+0.07)\,d\,(1+0.05)}$ $= 1+0.04+\beta+0.02+\beta$ $-0.07-0.05$, approx. $= 0.94+2\,\beta$ or, $L = 0.94+\frac{2}{1{,}333}$ M–30)
Ratio of probable rupture bending stress on section when green (70 per cent.) to actual stress on section at rupture (M per cent.), taking the above two effects to act jointly	$\frac{S_{green}}{S_M} = A \times K$ or, $X = 0.64+\frac{7\,M}{1{,}000}$, approx.	$\frac{S_{green}}{S_M} = B + L$ or, $Y = 0.738+\frac{3.75\,M}{1{,}000}$ approx.

tures must be used in drying. During the first drying stage up to the fibre saturation point the humidity is high and so the kiln maximum temperature must not approach 3 (*b*), *i.e.*, 150 deg. F. High temperatures and the expulsion of free water at too rapid a rate will also produce collapse of the cell walls and disaster. By arranging for the baffle temperature to be between 100 deg. F. to 120 deg. F., the maximum temperatures necessary to preserve the required humidity are not unduly high. During most of the experiments at Crawley the baffle or dew-point temperature has been 100 deg. F., a temperature easily maintained throughout the whole year, and the maximum kiln temperature has seldom been above 135 deg. F.

Precaution at Commencement of Operations.—Item 2 (*b*) indicates that the timber should be heated through before drying begins. A simple experiment shows that if wood is heated on one side and cooled on the other that the moisture, or water, will be driven from the heated to the cold side. Evidently, in the kiln, heat should penetrate into the interior of the timber before drying begins. At the commencement of the kiln operation then the air must be saturated with moisture and so live steam is frequently used, both to heat up the wood and provide also for a 100 per cent. humidity. Also from item 2 (*b*) results a quick and useful test to determine whether a piece of wood from kiln is dry. While still hot, a freshly-sawed end grain surface of the wood is placed on a cold piece of iron. The moisture, if any, in the wood will be quickly condensed on the cold metal.

APPENDIX II.

The Fibre Saturation Point in Jarrah.—In wood the water may exist in two conditions, viz., as free water contained in the cell cavities, and as hygroscopic or fibre moisture absorbed in the cell walls. In wet and green woods the water exists in both conditions, the free water usually having no particular effect upon physical properties such as shrinkage or strength. In determining the moisture content, both the free water and the absorbed are necessarily included. Consequently, in drying out a piece of wet wood, since the free water must evidently evaporate before the absorbed moisture in the cell walls can begin to dry out, there will be a period, providing, as is usual, that shrinkage does not take place, during which the strength remains constant, although varying degrees of moisture are indicated. But just as soon as the free water has disappeared and the cell walls begin to dry, the strength will begin to increase. This point is called the "fibre saturation point." Nearly all woods do not shrink until this fibre saturation point is reached, and with these, referring to their moisture-strength diagrams, the fibre saturation point will easily be recognised as the part where the steep curved portion is intersected by the straight line parallel to the moisture content axis (Fig. 13). It is usually between 25 per cent. to 30 per cent. moisture content. The fibre saturation point may evidently be determined by obtaining the moisture content when either shrinkage first takes place or an increase in strength takes place. However, in drying jarrah and other eucalypts, shrinkage takes place well before the 25 per cent. to 30 per cent. moisture content—even when green. Again, the strength also increases almost from the beginning of the drying, so that the point cannot apparently be obtained by the usual method stated above.

Shrinkage Analysis.—Fig. 11 gives graphically typical drying particulars of jarrah tangentially cut specimens, and Fig. 12 shows the relation between the percentage moisture content and the percentage shrinkage in the width (reckoned on dry dimensions at 10 per cent. moisture). It is seen that the observed results may be assumed to lie on pairs of intersecting straight lines, and evidently these intersection points will be near the fibre saturation point. The "rounding" near the intersection points was anticipated, for it is due to the fact that the critical change can only take place gradually through the thickness of the specimen. The full line is an average shrinking curve, the fibre saturation point being 30 per cent. Roughly, the shrinkage in the tangential direction from the fibre saturation point (30 per cent.) to dry (10 per cent.) is 4 per cent., based on dry (10 per cent.) dimension; between 70 per cent. and 30 per cent. moisture content the shrinkage is 3 per cent., making a total of 7 per cent. from green (70 per cent.) to dry (10 per cent.). Usually with "true" shrinkage (*i.e.*, due to contraction of cell walls) the tangential shrinkage is twice the radial, so that the radial shrinkage should be about 4 per cent. ÷ 2, or 2 per cent. between fibre saturation point and dry. Experiment shows that the radial shrinkage from green to dry is about 5 per cent. (reckoned on dry dimensions), so that the radial shrinkage between green (70 per cent.) and fibre saturation point (30 per cent.) is about 5 per cent.—2 per cent. = 3 per cent., which corresponds with the percentage shrinkage in the tangential direction. It appears from this result that the initial shrinkage (*i.e.*, up to fibre saturation point) is due to the wood cells, which are roughly circular, contracting as the free water is removed and thus diminishing equally in all directions. In other words, evidently, the cells are plastic and pliable when moist, and much free moisture causes them to distend, while the removal of water causes the cells to become more or less deflated, and perhaps collapse. Micro-examination is necessary in order to fix this idea. After the fibre saturation point is reached the cell walls begin to shrink and break up in a similar manner to all other timbers. An analysis of the shrinkage then from these experiments fixes the saturation point at about 30 per cent.

Strength Analysis.—The moisture bending strength diagrams for jarrah shown in handbook of W.A. Government Timber Tests, 1906, by Mr. Julius, are smooth curves. Fig. 13 shows curve, Jarrah No. 1, taken from the above-mentioned handbook, and also curves for pine and chestnut, respectively, which are typical of most timbers. Consideration showed that the absence of a horizontal line and a definite kink in the jarrah curves might be due to (i) the specimens tested being more or less case-hardened, or (ii) the early shrinking not being due to true cell wall shrinkage. Cause (i) was difficult to deal with now, and moreover, if considerable, would have been detected when the tests were made in 1906. Further analysis in cause (ii) showed that this was likely to lead to a rational explanation of the peculiar irregularity in the jarrah curves. Accordingly, using values obtained from the moisture-strength curve for jarrah, referred to above (Fig. 12), the strength of the timber was calculated on the basis that no shrinkage in drying takes place at all. In other words, average shrinking values were taken and the strength calculated on the assumed original green section, and not on the actual section at breaking as given, of course, in the curves of Mr. Julius. The table on page 324 gives particulars of the analysis necessary in order to compute the two-fold effect of the alterations in dimensions of cross-section, on the "bending rupture strength," due to the changes (i) in the section modulus, and (ii) in the density. The probable green dimensions of specimens having known dimensions when moisture content = M, computed from average curve, Fig. 12, are given in upper portion of columns. Since there is a kink in the "shrinkage" curve (*i.e.*, two intersecting straight lines) it will be necessary to have two separate sets of equations depending, of course, on the percentage moisture content. The alteration in the modulus of section due to shrinkage is shown, as well as the ratio of probable rupture bending stress on section when green (70 per cent., say) to actual stress on section at rupture (M per cent.). Evidently S, green, = A × S *m*. Knowing M and obtaining S *m* from curve (Jarrah No. 1), the value of the right-hand portion of this equation can easily be computed, and so S, green, obtained. Thus, M = 40 per cent.; B = 0·9325; from curve S at 40 per cent., moisture = 12,000 lb. per square inch; then S, green, = A × S *m* = 0·9325 × 12,000 = 11,200 lb. per square inch. Fig. 13, curve (Jarrah No. 2) shows the result of plotting obtained by this analysis. The alteration in the density (apart from the water) and the probable effect on strength is given in third row, and explains itself. Since (i) and (ii), above, may act jointly, it is necessary to consider their joint effect on the strength, and this is done in row No. 4. Thus, if M = 60 : Y = 0·963: from curve S at 60 per cent. moisture = 11,400 lb.; S, green, = Y × S *m* = 0·963 × 11,400 = 11,000 lb. Fig. 13, curve (Jarrah No. 3) shows the result of graphing the above joint effect. These curves (Jarrah Nos. 2 and 3) are similar in form to those of other timbers, and clearly show that if no shrinkage took place in jarrah in drying from green to a 30 per cent. moisture content condition, the "strength" would be constant, and from 30 per cent. moisture content to a dry condition an increase in "strength" takes place, apart from the no shrinking effect. Evidently, the 30 per cent. moisture content is about the fibre saturation point. It will be found that varying the shrinkage values (7 per cent. and 5 per cent.), within reason, has little effect on the value (30 per cent.) of the saturation point.

APPENDIX III.

PROVISIONAL INSTRUCTIONS FOR DRYING JARRAH.

General.—After being sawn, the material should be "picked" free from defects, carefully stacked and protected from the sun and wind, in covered sheds, and kiln dried as soon as possible, when green.

Stacking or Piling.—Timber must be evenly stacked or piled and held flat and straight while drying. Contact between wood and strips or distance pieces should in no case exceed 1½ in. in a direction lengthwise of the stack. Strips varying in thickness from 1 in. to 2 in. should be used for timbers of thicknesses of 1 in. to 4 in., respectively. Timber should be so arranged in the stack that drying will take place equally from both surfaces in planks, and from opposite faces in squares. The timber must be so disposed in the dry kiln as to permit of easy access on both sides of the stack.

Preparation of Samples, &c.—Representative samples must be inserted in the stack, to be kiln-dried in such a manner that they will be subjected to the same drying conditions as that portion of the stack where inserted, and so that they can be removed for periodical weighing in order that their moisture contents and, therefore, the mean moisture content of the stacks can be known at all times. Allow three samples for each 5,000 board feet or less of material. The samples should be at least 2 ft. long and should not be cut nearer than 2 ft. from the end of one of the pieces to be dried. The samples should be carefully weighed at least daily where the time of drying is ten days or less, and at least every other day for longer periods. They should be placed in a stack and distributed so as to be exposed to average, most rapid, and slowest drying conditions, except that they should not be placed on the top layer or bottom layer, and the temperature and humidity should be regulated according to the samples placed in the warmest part of the stack. The percentage moisture content of the sample should be determined by cutting sections 1 in. thick from both ends at the time the sample is sawed from the piece. These, after being weighed, are thoroughly dried and again weighed, the difference in the weights being due to evaporation of moisture, and the percentage original moisture reckoned on the dry weight is easily computed. The ends of the sample are to be given a thorough coating of asphaltum varnish mixed with lampblack, to prevent end drying, before placing them in the stack. After the dry weight of the sample has been determined, the average moisture condition of the pile during drying can be found by weighing the samples and calculating the condition of the stack from their weights.

Example:—

Original weight of sample, 8·65 lb.
Original moisture percentage (average of the two discs), 73.
Calculated dry weight of sample, 8·65 ÷ 1·73 = 5 lb.
Current weight, 6·18 lb.
Moisture in sample, 6·18 − 5 = 1·18 lb.
Current moisture percentage 1·18 ÷ 5 × 100 = 23·6 per cent.

In this manner a record must be kept of the percentage of moisture in the timber in the kiln. A standard test should be made on each sample before the timber be removed from the kiln.

Instruments.—Thermometers: At least one recording thermometer of approved make must be used in each dry kiln. This must be checked daily with a standard thermometer or a glass thermometer that has been calibrated to an accuracy of 1 deg. F. and placed in such a position as to record the maximum temperature to any portion of the stack. All glass thermometers should be accurate to 1 deg. F. Thermometer bulbs must be shielded from direct radiation of steam pipes or wet timber, cold walls or surfaces, and receive a free circulation of air.

Steaming.—Admit sufficient steam to saturate the air, at the stated temperature, as follows:—

(i) At the beginning of the drying operation, with green wood, 6 hours for each inch of thickness, at a temperature not over 120 deg. With previously air-dried wood, 8 hours for each inch in thickness.

(ii) Near the end of the drying, in order to eliminate internal stresses (case-hardening) at a temperature not to exceed 140 deg. F. and for a time not to exceed 3 hours.

Temperature and Humidity.—Average or mild conditions are here specified. Lower temperatures and higher humidities are permissible. In no portion of the stack should the average operating temperature exceed, or the average operating humidity fall below, nor should any piece of wood be subjected to more severe average operating conditions than the figures given in the table below. However, an accidental rise in the temperature and decrease in humidity will not damage the timber, providing the period of time is less than 2 hours, and during which the rise in temperature does not exceed the average specified temperature by more than 10 deg. F., nor the humidity be more than 10 per cent. less than the average specified humidity. Furthermore, the progression from one specified stage to the next must proceed along uniform lines.

Maximum Average Drying Conditions.

Stage of Drying.	Maximum Temperature.	Approximate Relative Humidity Percentage.	Baffle Temperature.
	deg. F.		deg. F.
At the beginning ..	110	85	105
After fibre saturation is passed (30 per cent.) ..	115	75	105
At 20 per cent. moisture ..	120	65	105
At 15 per cent. moisture ..	130	50	105
At 12 per cent. moisture ..	135	45	105
At 8 per cent. moisture ..	140	40	105
Final	140	40	105

[More severe drying conditions can be used (*i.e.*, commencing with 115 deg. F. baffle temperature) without visible injury of any kind, but on account of injury to strength and introduction of internal stresses, through the varying density and moisture contents of the pieces, the milder conditions are (provisionally) specified.]

Tests of Material after Drying.—At the end of the run, standard tests must be made for moisture content and case-hardening. Material for these tests should be taken from each of the samples in the stacks and from other pieces, which should be representative of the dried stock, at least three pieces for every 5,000 ft. or less, and taken from different parts of the kiln. Two adjacent sections, 1 in. thick, should be cut from the centres of each of the samples and pieces of stock. Due precaution must be taken to prevent moisture evaporation between the time of sawing and the time of weighing these sections. The first section should be dried and the moisture content obtained by the standard method previously referred to. The other section, if cut from a 3-in. plank, should be slit in the longest direction, parallel to the faces of the piece, into six equal tongues or prongs, leaving about ½ in. solid wood adjoining the prongs at one end of the section. The second prongs from both sides are to be broken out, leaving two outer prongs and two in the middle (see Fig. 10). The curving of these prongs indicates the degree of case-hardening. If the prongs remain straight it indicates perfect conditions as to the stress and moisture. If the outer prongs bend in, it means that the piece was case-hardened. If they bend out, it means that the piece was oversteamed in final steaming. If the centre tongues first bend outwardly and finally inwardly, it shows that the centre was not thoroughly dry. The material less than 2 in. thick three tongues should be sawed instead of six, and the inner one removed.

Final Moisture Conditions.—An average dryness of approximately 8 per cent., unless otherwise specified is required with a variation of individual sticks from not less than 5 per cent. to not more than 11 per cent. Upon removal from the kiln the wood should be allowed to remain in a room with all parts under uniform shop conditions at least three weeks for 3-in. material, and other sizes in proportion, before it is manufactured.

TEST OF SANDY FOUNDATIONS FOR BRIDGE PIERS.

AN interesting experiment was recently carried out on the bearing power of sandy material for foundations, and we give below an account of the work written by Mr. Arthur Richards, deputy county engineer, Columbus, Ohio, for which we are indebted to the *Engineering News-Record*.

A unique foundation soil test was made at one of the piers of the Broad-street Bridge, Columbus, Ohio, in order to determine the bearing power and settlement under load of the sandy material below the pier. This test was conducted after the pier had been completed up to the springing line of the main arches, so that the sand was in a normal loaded condition and confined to preclude any upward movement adjacent to the bearing block. Large stone taken from an old abutment was used for the load, and applied on a platform at the top of a long mast extending through the pier. This platform was loaded rapidly up to about 11,500 lb. per square foot and finally to 18,350 lb., without any special consideration as to time of application; the object was to determine the action under long periods of load.

The test shaft was placed near the centre line of the bridge in a sump opening through the pier which had been used to keep the cofferdam unwatered as the concrete construction proceeded. The bottom of the sump was dug out about 3 ft. lower than the footing of the pier, and it was this lower elevation at which the test shaft was begun. The first section of the shaft-box was 10 ft. long. In the lower end was inserted a built-up block of wood 24 in. by 24 in. by 24 in., which was nailed to the shaft-box to prevent upward movement, but which could be displaced downward when a few hundred pounds of weight was placed upon it. The sump was filled with excavated sand up to the level of the bottom of the pier footing, and the concrete placed in this sump opening was carried up around the shaft-box. This box was 2 ft. by 2 ft. in cross-section and was carried vertically up to the elevation of the springing line.

Results of Soil Test at Arch Bridge Pier.

Time.	Time Interval.	Pounds per Sq. Ft.	Total Settlement.	Time.	Time Interval.	Pounds per Sq. Ft.	Total Settlement.
a.m.	hr. min		ft.	p.m.	hr. min.		ft.
3-27-19	—	—	—	2.30	0 5	11,520	0·05
10.00	—	1,275	0·00	3.00	0 30	11,520	0·06
3-28-19				3-29-19			
p.m.				a.m.			
1.37	—	1,036	0·00	10.00	19 0	11,520	0·06
1.40	0 3	2,780	0·00	10.20	0 20	12,275	0·06
1.44	0 4	3,742	0·00	10.25	0 5	13,125	0·08
1.50	0 6	4,456	0·00	10.30	0 5	13,980	0·10
1.53	0 3	5,210	0·00	10.40	0 10	14,705	0·11
1.56	0 3	6,215	0·01	10.45	0 5	15,699	0·12
2.00	0 4	7,165	0·02	10.50	0 5	16,599	0·13
2.05	0 5	8,036	0·03	10.55	0 5	17,250	0·14
2.10	0 5	8,897	0·05	11.00	0 5	18,350	0·15
2.15	0 5	9,832	0·05	3-31-19			
2.20	0 5	10,488	0·05	8.00	45 0	18,350	0·15

Shortly after the pier was completed a 10-ft. flood occurred in the Scioto River, which delayed the beginning of the test for two weeks. Just prior to the placing of the test mast in the shaft, about 2 ft. of silt and sand which had been deposited therein during the flood was blown out of the shaft with a steam jet. The elevation of the water during the test period within the shaft and about the pier was 702, as illustrated in the drawing.

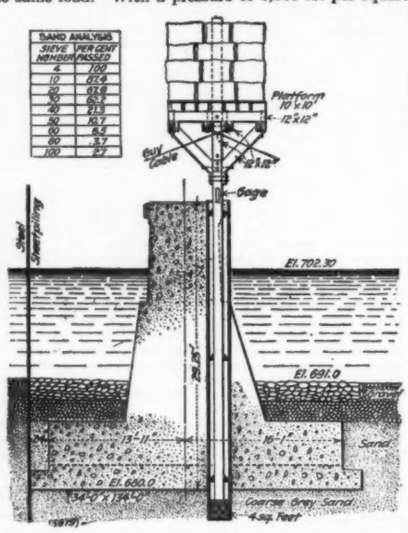
A 12-in. by 12-in. fir derrick boom was used as the loading mast, with guards to keep it vertical during the test and prevent deflection. The test platform, as illustrated in the photograph and drawing, was built up of 12-in. by 12-in. timbers. Some of the bolt washers, because of excessive weight on one side to balance the platform, were indented into the timber not more than $\frac{1}{8}$ in. during full loading, and the lower 12-in. by 12-in. brace on one side had a deflection of several inches. The large stone used for loading the mast varied in size, shape and weight, so that it was difficult to keep the load properly balanced at all times. Guy cables were therefore used to hold the mast in position during unequal loading, but for the test periods of 19 hours and 45 hours the platform was evenly balanced. **A rope was provided and extended over the top of the platform for use by the workmen as a life line in the event of the failure of the platform.**

The large stones used in the test were taken from the west abutment of the old bridge and were placed on the platform by a derrick; each stone was numbered and measured and its weight was computed. This stone was red and yellow sandstone and its weight per cubic foot was obtained by taking various samples, about 20 lb. each, and finding their displacement in water. The weight per cubic foot used in calculating the platform loading was 130 lb.

The platform was constructed and attached to the mast before the latter was placed in the shaft. The entire weight of mast and platform was dropped clear of the last foot in order that the block at the bottom of the shaft would be loosened from the shaft-box. A gauge divided into hundredths of a foot was placed on the mast near the top, the indicator was adjusted, and the loading was begun the next day.

All the piers of the bridge rest upon coarse grey sand which extends below the footings about 40 ft. and overlies about 20 ft. of blue hardpan on limestone bedrock. The total maximum toe pressure which will exist at any pier is computed to be about 8,000 lb. per square foot, and the foundation soil test was made primarily to determine whether any undue settlement would take place. The time interval in loading therefore received no special consideration, as it was desired to see what action took place under a load over a long period of time. The platform was therefore loaded rapidly until a load of 11,520 lb. per square foot was obtained. As indicated in the table of results, it is seen that there was a total settlement of 0·06 ft. shortly after the first full load was applied, and that this remained constant for a period of over 19 hours. Additional weight was then applied until a pressure of 18,350 lb. per square foot was obtained, with a total settlement of 0·15 ft., which remained constant for a period of 45 hours.

It is evident that as the pier was being constructed up to the springing line, a small settlement had taken place, and that as the arches and the fill over the arches are placed there will be additional small settlements. From the test results it would appear that in this case after settlement had occurred for a specific load there would be no additional settlement in the future under the same load. With a pressure of 8,000 lb. per square



foot a total settlement of 0·04 ft. can be assumed; and as probably half of this will occur before the arches and superimposed loads are placed, it will only be necessary to provide for 0·02 ft. settlement when considering the placing of the arches. This is considered negligible.

During the construction of the next pier it is intended to embed a vertical steel rod in the footing, and then make note of the settlement which takes place during the remainder of the construction of the bridge.

As the load was removed from the platform the gauge was observed; after all the stone had been removed there was no change in the reading. The lower end of the mast was examined, and one end was found to be slightly crushed, although the general appearance indicated that the load had been evenly distributed. Improvements in the test apparatus would result if a steel plate on top of the bearing block and another at the bottom of the mast were used, and also by framing around the mast at the gauge in order to prevent sidewise motion.

The cost of the test was as follows:—

	Dols.
Test shaft, labour and material	176
Platform, labour and material	172
Placing and loading platform	135
Dismantling platform	65
Extra, concreting test shaft	37
State liability insurance	32
Total	617

The Broad-street Bridge is a reinforced concrete structure consisting of seven arch spans, and is being built by the Carmichael-Cryder Company, of St. Louis, at a cost of 650,000 dols. The work is being done for Franklin County, Ohio, under the supervision of John Dun, county engineer.

CARBON ELECTRODES FROM NATURAL GAS.—In view of the finds of oil and natural gas in the United Kingdom, it may be of interest to point out that the natural gas, especially when not sufficiently plentiful for lighting and power purposes, may be cracked to produce electrode carbons. The gas is passed through pipes which are suitably heated so as to produce a mixture of soot and tar. The mixture is briquetted and then baked. The electrodes so obtained are free from ashes, and the proportion of tar in them can be varied by adjusting the temperature to which they are heated. According to the *Journal für Gasbeleuchtung* of March 17 last, Dr. E. Szavasy, of Budapest, was making carbon electrodes for the metallurgical works of Transsylvania in this way from the natural gas, which is found in some parts of Hungary; but the news was probably older than the renewed political troubles of those countries.

CATALOGUES.

Electric Furnaces.—Resistance furnaces, with quicker renewable heater units, are shown in a catalogue from Messrs. A. Gallenkamp and Co., Limited, 19, Sun-street, Finsbury-square, E.C. 2. Full particulars and prices are given for furnaces, and also for renewable parts and accessories.

Telephones.—The telephone system made by Dictograph Telephones, Limited, Denman-street, London Bridge, S.E. 1., enables a person to speak to one or several others simultaneously in distant parts of the same establishment. The transmitter rests on the table and may be spoken to and heard from without mouthpiece or ear piece. The system is fully described in a special catalogue.

Planing Machine Drive.—A pamphlet written by Mr. W. L. Miller, and published by the British Westinghouse Company, Limited, Trafford-park, Manchester, deals with the application of the company's electric motor drive to planing-machines. As compared with the belt drive, an increased range of cutting speeds, a quicker return stroke and a saving in overtravel are effected.

War Work Record.—The 93rd booklet of the Baldwin Locomotive Works, Philadelphia, U.S.A., contains a record of war work. Locomotives figure largely in this record, from the most powerful steam types down to steam and petrol types of 23½ in. gauge—over 5,500 engines in all. In addition six and a half million shells were made, a number of heavy gun mountings, including railway, caterpillar and foundation types, and a great deal of other munitions. A dozen railway mounts were made for 14-in. navy guns on 12 pairs of wheels and giving a firing elevation of 45 deg. One of the most interesting though unpretentious records of war work.

Wood Planing Machine.—A very powerful machine for planing wood is shown in a supplementary cataloguepage from Messrs. Thomas Robinson and Son, Limited, Rochdale. It is capable of planing at one passage four sides of hard wood up to 16 in. broad by 8 in. thick. The piece is automatically carried through the machine, which holds it straight against any twist there may be in the wood, at any of four rates of feed from 12 ft. per minute to 45 ft. per minute. The hard dry oak scantlings used in railway rolling-stock construction are one of the largest items of work for this kind of machine The lubricating oil is lead to each of the main bearings by pipes from oil boxes fixed to the side frames. The machine drive consumes about 50 h.p. or 60 h.p. under full load.

Train Rails.—A catalogue from Messrs. Hadfields, Sheffield, will convince the careful reader that at least one thing is made as well as it can possibly be made, viz., tramway junctions, crossings and general track. The catalogue does not make this claim in set terms—the proof is rather in the entire disregard of the usual commercial persuasion or of any other consideration but quality. As six years is a long life for a tramway junction, and as the work of replacing a set is probably greater than the cost of the rails, the importance of quality is easily understood. These junctions and rails are made of manganese steel. It might be thought that there was not much room for mechanical ingenuity in the movement of a tramway point, but those who carefully examine Hadfield's Hecklapoint will think differently if they have observed the effects of wear on more obvious kinds of designs. Tramway engineers will be interested in this catalogue.

THE "DEGRADATION" OF GASES.—The term "degradation" of gases has been proposed by W. Nernst to indicate the condition to which gases must be reduced at extremely low temperature. It follows both from the quantum theory and from Nernst's heat theorem that at very low temperature the general law $pv = R.T.$ can no longer hold, even for the perfect gas, since the gas pressure measured at constant volume is then independent of the temperature. Such a degenerated gas behaves more like a solid; whilst in a solid, however, the particles remain at definite distances apart, even at zero pressure, compression apparently giving rise to forces of repulsion and dilatation to forces of attraction. Repulsion forces alone seem to exist in a gas which always retains its characteristic property of filling the space offered to it at uniform density. The two atoms of a hydrogen model are kept at definite distance by forces which can be calculated from the Bohr-Debye model; but such considerations, Nernst suggests, do not enable us to calculate the opposing forces, which are set up when the distances are changed by external forces. He proposes, in a communication to *Akademie der Wissenschaften*, Berlin, February, 1919, a new equation of state, and shows that the degradation becomes explicable when forces of repulsion—relatively weak, not strong—of the character of a valency are assumed to act between homogeneous molecules. These forces would be inversely proportional to the mass of the molecules and to the third power of their distance apart. Since, further, these forces must be the same as those manifested during the impact of molecules, the free path of the molecules and allied phenomena can be calculated by a new set of formulae. Nernst performs these calculations for hydrogen and also for helium, and he shows that the internal friction of hydrogen, at low temperatures, can be determined with fair accuracy solely from the mass of the hydrogen atom, its molecular velocity and the Planck constant. These considerations are only to hold for very low temperatures, but they imply an indirect proof of the reality of a gas degradation.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

AERONAUTICS.

127,847. The Sopwith Aviation Company, Limited, Kingston-on-Thames, and H. G. Hawker, Kingston-on-Thames. Cowls. (3 *Figs.*) May 29, 1917.—This invention consists of an improved means of attaching and securing the dismountable cowl employed to cover in the engine of aeroplanes. The plate *a* on the front of the fuselage on which the engine is mounted is provided with a peripheral tubular ring *b*. In the outer circumference of this ring *b*—hereinafter called the cowl ring—is formed a circumferential channel *b*1. On the back edge of the cowl *c* is an inward projecting circumferential flange *c*1. The shape of the flange *c*1 in cross-section and its circumferential length are such as will enable it to engage

Fig. 1.

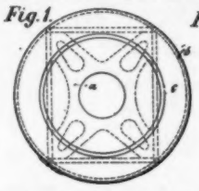
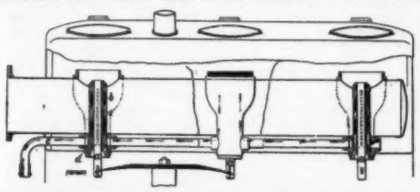


Fig. 2.

with the circumferential channel *b*1. To enable the cowl to be placed in position on the cowl ring, the back edge of the cowl is slit at one or more places and it is held in position by a flexible cable *d*, which lies in the channel *c*2 in the cowl. The flexible cable is connected at each end to a straining device, said devices being connected at their other ends to a bracket carried by the cowl or by the cowl ring, so that the binding device is permanently anchored to one or other of said parts. The length of the flexible cable is such that a few turns of one or other or both of the straining devices will either slacken the cable so as to free the cowl or tighten same so as to bind it securely to the cowl ring (*Accepted June* 25, 1919.)

127,867. Peter Brotherhood, Limited, Peterborough, C. W. Bryant, Peterborough, and G. F. Jones, Peterborough. Aero Engines. (1 *Fig.*) June 8, 1917.—The invention relates to aero engines and provides improved cooling of the exhaust valve. The invention consists in an exhaust valve guide comprising an outer shell welded to an inner shell and screwed into a fitting supported from the exhaust valve seat, passages being provided by which water is guided between the inner and outer shells. Each of the exhaust valve stems *a* is



provided with an exhaust valve guide comprising an outer shell *b*, to which is welded at its inner end an inner shell *c*, guiding strips being provided lying longitudinally along the space between the shells to guide the water from the outer end to the inner end and back to the outer end, as shown by the arrows. The guide is screwed into a fitting *d* supported from the exhaust valve seat, and apertures are provided in the fitting *d* for pipes *e* by which water is led into and out of the guide. Water is supplied under pressure, and two or more guides may be connected up in series and the water may be finally discharged into the main water space surrounding the cylinders. (*Accepted June* 25, 1919.)

129,029. The Siddeley-Deasy Motor Car Company, Limited, Coventry, and F. M. Green, Coventry. Landing Chassis. (4 *Figs.*) September 28, 1917.—This invention relates to landing chassis of aeroplanes of the type in which the shock absorbing members are controlled partly by hydraulic means and partly by springs, and it consists of an improved construction of shock-absorbing strut for connecting the axle carrying the landing wheels with the fuselage. Two tubular elements *a*, *b*

Fig. 1.

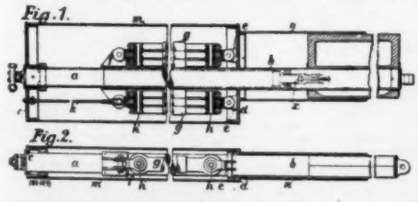
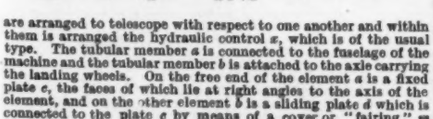


Fig. 2.



are arranged to telescope with respect to one another and within them is arranged the hydraulic control *x*, which is of the usual type. The tubular member *a* is connected to the fuselage of the machine and the tubular member *b* is attached to the axle carrying the landing wheels. On the free end of the element *a* is a fixed plate *c*, the faces of which lie at right angles to the axis of the element, and on the other element *b* is a sliding plate *d* which is connected to the plate *c* by means of a cover or "fairing" *m* which is shaped to give this part of the strut an elliptical shape. On the sliding plate *d* are mounted two brackets *e*, *e*, between which and two similar brackets *f*, *f*, mounted on the inner end of the element *b* are arranged the controlling springs *g*, each of which consists of a length of rubber cord which is wound around pins *h*, *h*1, carried by the two groups of brackets *e*, *f*. Extending between the plate *c* and the group of brackets *f*, *f*, are one or more inextensible flexible couplings *k* for the purpose of limiting the relative movement of the two tubular elements *a*, *b*. The plate *d* also carries a second cover or "fairing" *n* which also has an elliptical shape and co-operates with a similarly-shaped housing of mounted on the free end of the member *b* so as with said cover or "fairing" *m* to preserve the elliptical shape of the strut through its entire length. (*Accepted July* 16, 1919.)

ELECTRICAL APPARATUS.

129,027. Spear and Jackson, Limited, Sheffield, and G. Marriott, Norton, Sheffield. Electric Furnaces. (2 *Figs.*) September 27, 1917.—The invention relates to electrode holders for electric furnaces of the type in which a two-part metal belt with tail pieces and attached curved contact pieces is adapted to close upon the electrode to be held. According to this invention, the improved electrode holder with an open-ended contact belt *a* is formed to encircle an electrode, and has an arm or tail piece *a*1 secured between busbars *b*1 connected with the source of electric supply. This contact belt *a* has upper and lower outwardly-extending flanges *a*2, *a*3, between which is placed on either side a hinged steel clamping belt. This clamping belt is formed in two parts, each of which consists of a straight portion *c*1 (secured to the bus-bars *b*1 and the arm *a*1 of the contact belt *a*)

Fig. 1.

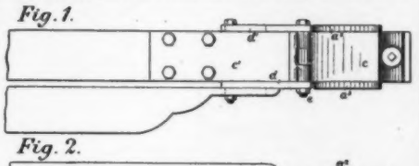
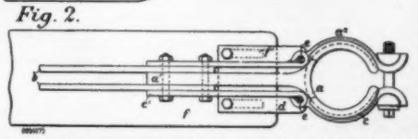


Fig. 2.



and a hinged curved portion *c*, the two curved portions encircling the contact belt *a* and having their outer free ends connected by a bolt and nut. The lower edges of the straight portion *c*1 of the clamping belt *c* rests upon a steel plate *d* which has at its forward end two holes, through which the bolts *e* which form the hinge pins of the belt pass. A similar plate *d*1 is in like manner secured on the upper edge of the clamping belt. The rear ends of these plates *d* and *d*1 also have holes to receive bolts which pass through the bracket *f* supported from one end of the furnace masts, and through both of the said plates *d* and *d*1. The holes *f*1 in the bracket *f* may be elongated to allow of adjustment of the electrode horizontally as may be required. Alternatively the holes in the upper and lower steel plates *d* and *d*1 may be elongated to obtain the same result. (*Accepted July* 16, 1919.)

128,359. J. B. Tucker, Birmingham. Electric Switches. (3 *Figs.*) June 12, 1918.—This invention refers to the type of switch involving a number of circuit closers adapted to be operated individually and selectively, and also collectively. The invention comprises a switch of this type in which the individual switch operating members are so combined with the spindle appertaining to a master lever that said individual switch-operating members are individually detachable from the said spindle transversely to the axis of the latter. As a result of this combination it is possible to detach the plate carrying any individual switch-operating member from the box without removing, deranging or interfering with the spindle, switch-actuating part appertaining thereto, or with any of the other plates or switches carried thereby. A box *a* is closed by a series of separate plates *b*, each of which carries a switch. The switch carried by each plate comprises an operating lever *e* pivotally mounted to the rear of the plate *b*, said operating member involving a lever which projects through the plate. Inwardly of the plate the operating member also carries an arm *e* which carries a contact maker adapted to be brought into and out of contact with a stationary contact *f*. The operating member involves a drum *h*, and the said drum and its trunnions are

Fig. 1.

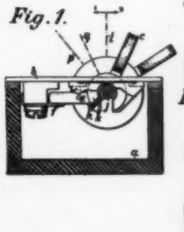


Fig. 2.

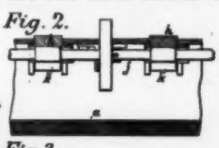
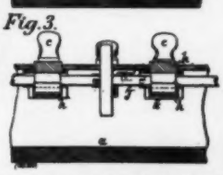
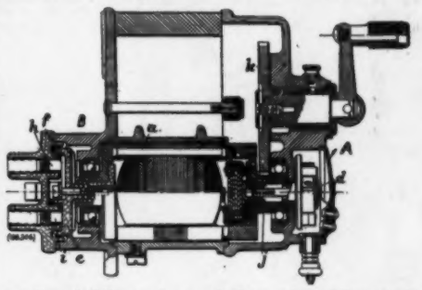


Fig. 3.



concentrically bored to accommodate a master spindle *j* located co-axially with the operating member. A segment of the drum *h* is cut away and the spindle *j* is furnished with a projection *k*, which extends within the segment-shaped opening in the drum. The spindle *j* is furnished with a series of the said projections, one for each individual operating member, the said projections being located in a common plane. When the master spindle is in an intermediate position indicated by line *l*, any individual switch-operating member *c*, *h*, can be displaced either into the closed or open position without any movement being imparted to the master spindle *j*, this action being permitted by the segment-shaped opening in the drum portion *h* of the individual operating member. Rotation of the master spindle *j* has the effect in one direction of displacing all of the individual operating members into the closed position, and in the other direction into the open position. If certain of the individual operating members are in the closed condition, and others are in the open condition, rotation of the master spindle in one or other direction has the effect of displacing into the closed or open position all of those individual operating members which are respectively in the open or closed condition. Line *p* indicates the third position of the spindle *j*. Line *q* indicates the other position of the lever *e*. (*Accepted July* 2, 1919.)

128,306. A. H. Midgley, Acton Vale, and C. A. Vandervell and Co., Limited, Acton Vale. Magnetos. (1 *Fig.*) July 28, 1917.—This invention relates to an improved starting magneto for internal combustion engines of the kind comprising a distributor and in which the armature is driven by a starting handle or its equivalent through an intermediate driving gear. According to the present invention, the intermediate driving gear driven by the starting handle is arranged at the same end as the contact breaker and the high-tension terminal is brought out at the



opposite end of the armature. *a* is the armature of the magneto, which is provided with a primary and secondary winding; *d* is the circuit breaker, which is arranged at the end A of the machine; *e* is a distributor arranged at the end B of the machine and provided with a segment *f* which is connected to the high-tension terminal and is adapted alternately to make contact with two brushes *h* and *i* connected to the distributors of the engine; *j* and *k* are the two members of a driving gear which is arranged at the end A of the machine between the armature *a* and the circuit breaker *d*. (*Accepted July* 2, 1919.)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

127,856. The Villiers Engineering Company, Limited, Blakenhall, Wolverhampton, and G. Funck, Coventry. Internal-Combustion Engines. (3 *Figs.*) June 2, 1917.—This invention relates to air-cooled cylinders for internal combustion engines. It has been proposed to cover a cylinder body of iron or steel with a jacket of high heat conductivity, such as aluminium, having cooling fins, and according to this invention the jacket is provided with gas passages or valve guides or with

Fig. 1.

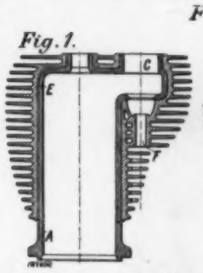
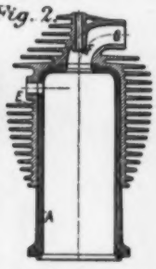
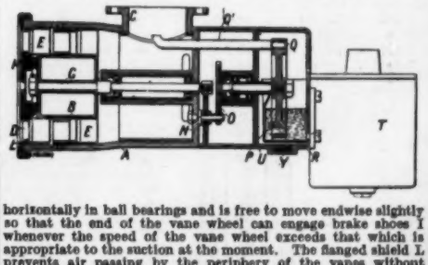


Fig. 2.



both. A cylinder body A is formed as a casting and is closed at the upper end. A passage for the insertion of the valves is indicated at C, and a valve seating is formed in the cylinder body. A radiating jacket E is cast on and provided with a valve guide F. In the construction shown in Fig. 2, the body A is of plain circular form, so that it can be readily machined inside and out. In this case the radiating jacket E is provided with a gas passage G and valve guides, one of which is shown at F. (*Accepted June* 25, 1919.)

128,269. H. Blackburn, Doncaster. Carburettors. (1 *Fig.*) July 6, 1917.—This invention relates to carburettors of the kind in which the suction of the engine causes a vane wheel to revolve in the intake; which vane wheel is geared to a perforated disc dipping in a bath of liquid fuel located outside the intake, the fuel being picked up by the perforations in the disc and sucked therefrom through a pipe communicating with the intake. According to this invention, the vane wheel is mounted with its axis horizontal, a shield is provided to prevent air leaking past the periphery of the vanes, and an overflow jacket is provided to catch excess fuel from the perforated wheel and from its fuel tank. A is a casing containing a vane wheel B connected at C to the engine intake. The air is drawn in at D and causes the vane wheel B to revolve. The vane wheel spindle G is carried

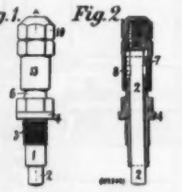


horizontally in ball bearings and is free to move endwise slightly so that the end of the vane wheel can engage brake shoes I whenever the speed of the vane wheel exceeds that which is appropriate to the suction at the moment. The flanged shield L prevents air passing by the periphery of the vanes without exerting turning action on the vane wheel. The spindle G passes through the end wall N of the casing A to gearing O connected with a wheel P having perforations Q. The wheel P rotates in a fuel tank R, and the liquid fuel caught up by the perforations Q is sucked into the intake through a pipe Q1 as each perforation registers with said pipe. The fuel tank R is fed from a float chamber T, and an overflow jacket U surrounds the tank and perforated wheel to catch excess fuel, which can be carried away through a pipe connected to the opening V. (*Accepted July* 2, 1919.)

128,249. The Birmingham Small Arms Company, Limited, Small Heath, Birmingham, and R. Nicholls, Redditch. Internal-Combustion Engines. (6 *Figs.*) July 3, 1917.—This invention relates to valve gear for internal

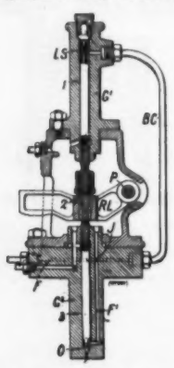
combustion engines, and refers more particularly to adjustable tappets. According to the form of this invention shown, the guide sleeve 1, which slidably carries the tappet rod 2, is provided near its lower end with a screw-threaded portion 3, whereby it can be mounted in position in the wall of the crank-case, and near its middle is provided a flange part 4 on which are formed hexagonal flats or other means to facilitate its insertion in the wall of the crank-case. The upper part 6 of the guide sleeve 1 is provided with slots or grooves 7, and on the tappet rod 2 are formed lugs or projections 8 which slidably engage with the slots or grooves 7 and prevent a turning movement of the tappet rod in the sleeve. The upper end of the tappet rod 2 is arranged

Fig. 1. Fig. 2.



to protrude above the upper outer end of the guide sleeve 1, and the protruding part is screw-threaded to receive the adjusting members hereafter described. On the upper end of the tappet rod 2 is mounted a cap 10 which is screw-threaded to engage with the screwed end thereof, its upper face being shaped and adapted to engage with the lower end of the valve stem, and its periphery is hexagonal or otherwise shaped to be engaged by a spanner. Below the cap 10 is mounted a combined lock nut and sleeve 13, the sleeve part being adapted to slidably embrace the upper part 6, and serves to exclude the admission of dust or dirt into the guide sleeves, and also serves to form an additional support for the tappet rod 2, while its upper part is internally screw-threaded to engage with the screw-threaded part of the tappet rod 2, and externally is provided with hexagonal flats whereby it may be rotated by a spanner or other tool. (*Accepted July* 2, 1919.)

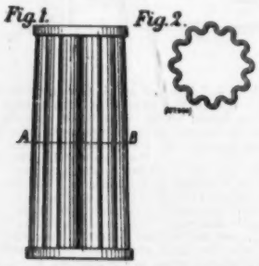
127,980. R. P. Doxford, Sunderland, and K. O. Keller, Sunderland. Fuel-Injection Valves. (1 *Fig.*) June 11, 1918.—This invention relates to fuel-injection valves for oil engines. In the improved fuel-injection valve according to the present invention 1 is the upper part or pilot ram of the valve and 3 is the needle valve proper. The middle part is the pusher rod 2, operated by the rocker lever R L pivoted to the stationary pivot P. The parts 1, 3, the former being slightly larger in diameter than the latter, are separate from, but abut against, the part 2, the three parts being so formed that their abutting surfaces are parallel to one another and normal to the vertical axis of the parts 1, 2, 3. In the cylindrical guide G1 the part 1 is a fluidtight sliding fit, and its top end serves as a piston therein.



On its top end bears a light spring L S, kept in place by a screw and gastight plug. In the cylindrical guide G3, which is aligned with the guide G1, the needle valve proper 3 is a fluid-tight sliding fit; it serves as a piston therein, and from its lower end its tapered tip extends into the fuel-opening O leading into the engine cylinder. A pipe B C, which is a pressure-equalising conduit, maintains constant communication between the top end of the upper cylinder G1 and the bottom interior of the lower cylinder G2. It communicates with the latter by making a junction at J with the fuel inlet conduit F, F1, leading from the source of oil under pressure. The lower end of the upper cylinder G1 and the upper end of the lower cylinder G2 serves respectively as guides for the upper and lower ends of the pusher rod 2, which extend into them as shown. (*Accepted June* 25, 1919.)

127,986. J. A. Yeadon, Leeds. Vertical Retort. (3 *Figs.*) June 12, 1918.—The invention consists of a vertical retort. According to the invention, the body of the vertical retort is of a "corrugated" or fluted section, the corrugations being vertical and extending from the top to the bottom of the retort body

Fig. 1. Fig. 2.



where exposed to the fire. The sectional thickness of the corrugations is uniform throughout. The number, pitch and form of the corrugations in each retort can be modified as required to suit the proportions of the retort and the conditions under which it is intended to be worked. Fig. 1 is an elevation of the vertical retort body, which may be made circular or oval, and showing its vertical corrugations. Fig. 2 is a horizontal section on the line A B. (*Accepted June* 25, 1919.)

GUNS AND EXPLOSIVES.

128,243. Sir A. T. Dawson, Westminster, London, and Sir G. T. Buckham, Westminster, London. Ordnance Breech Mechanism. (7 *Figs.*) June 28, 1917.—This invention relates to ordnance breech mechanism of the breech screw carrier type, in which the carrier is provided with an actuating crankshaft for unlocking the breech screw. According to the invention, means are provided whereby the actuating crankshaft can be removed from the carrier without necessitating the dismantling of any of the other parts of the breech mechanism. The said means may comprise a bearing C (herein termed the retaining bearing) between which and the actuating crankshaft B, and in contact with both these parts, a sleeve D (herein termed the

Fig. 1. Fig. 2.

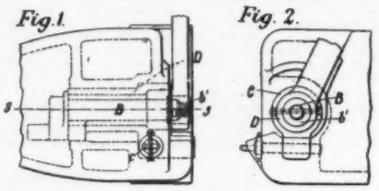
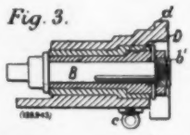


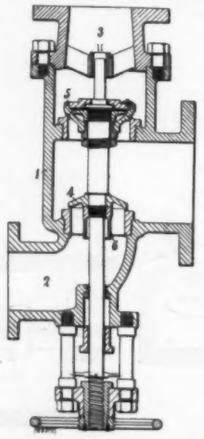
Fig. 3.



hand-lever sleeve) connected to the shaft is disposed; the said retaining bearing is detachably held in position in a hole in the carrier, which hole is of such size as to enable the crank of the actuating crankshaft to pass through it. The retaining bearing and the hand-lever sleeve bear at their inner ends against a collar or shoulder *b* on the actuating crankshaft, and the retaining bearing bears at or near its outer end against a shoulder *d* in the hand-lever sleeve, the said bearing and sleeve being held in their assembled condition with respect to the crankshaft by suitable means which may comprise a nut *b*1 on the crankshaft arranged in contact with the outer end of the sleeve. (*Accepted July* 2, 1919.

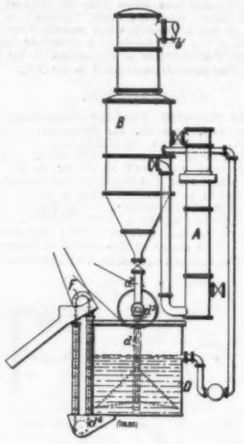
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

128,373. R. and W. Hawthorn, Leslie and Co., Limited, Newcastle-on-Tyne, R. B. Armstrong, Newcastle-on-Tyne, G. Paterson, Newcastle-on-Tyne, and Cockburns, Limited, Cardonald, near Glasgow. Steam Superheaters. (3 *Figs.*) June 17, 1918.—This invention relates to valve devices of the type including two operatively-connected valve elements proper engageable with separate seats and controlling separate passages, through one of which passages flows superheated steam and through the other of which flows saturated steam, whereby to control the proportions of superheated and of saturated steam to be admitted to steam engines, without interference with the continuity of circulation through the superheater elements when manœuvring with the main engines for example. The invention consists in improved devices of this type, comprising a balanced valve system in which there is a double beat valve having provision to ensure maintenance of balance of the valve while taking account of inequalities of the amounts of superheated steam and saturated steam to be passed, as hereinafter



more fully described. The construction illustrated comprises a double-beat valve operating in a casing 1, having separate inlets 2 and 3 communicating respectively with a source of superheated steam supply and with a source of saturated steam supply, one beat 4 controlling the passage of superheated steam and the other beat 5 controlling the passage of saturated steam. To permit maintenance of the balance of such double-beat valve, the valve elements 4, 5, are of equal area; in order, however, to take account of the circumstance that the quantity of superheated steam to be passed may be different from the quantity of saturated steam to be passed, one of the beats, say, the beat 4, or one of the seat portions, say, the seat portion of the valve opening for superheated steam, may be provided with an apron 6, serving more or less to constrict the relative passage, it being understood that the steam passed through each valve opening is proportional to the clear area, so that less steam will pass through a constricted opening than through an unconstricted opening. (*Accepted July* 2, 1919.)

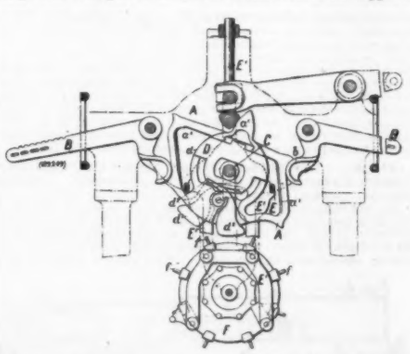
128,015. L. A. Fullagar, Harborne, J. A. Reavell, Beckenham, and Kestner Evaporating and Engineering Company, Limited, Westminster, London. Evaporators. (1 *Fig.*) June 18, 1918.—This invention has reference to evaporating apparatus for use in removing salts from saline solutions of the type in which one or more evaporators and a separator are so connected that the saline solution circulates through both, the salt being deposited in the latter, and the water evaporated off in the former. According to this invention, there is provided in the receptacle or tank into which the deposited salt and a portion of the mother liquor from the separator passes, means whereby such liquor is automatically kept in a constant state of agitation and the salt in suspension, while such salt is being continuously and automatically removed from the tank or receptacle. A is the evaporator to which the liquor to be concentrated is supplied, B the separator through which the liquor circulates and in the lower chamber of which the salt is deposited, the vapours given off being conducted away through pipe *b*1. D represents the tank into which the deposited salt from the separator is withdrawn and *d*1, *d*2, the conduit down which the



deposited salt and the mother liquor which passes out with it falls. Now, according to this invention, in order to automatically and continuously remove the deposited salt from the tank D, this tank is fitted centrally with a vertical shaft D5 to the lower end of which arms carrying ploughs are attached. The shaft is revolved by gearing, causing the ploughs to travel round near the bottom of the tank and consequently keep the liquor in said tank in a constant state of agitation, thereby moving the deposited salt with the mother liquor through an opening in the bottom of the tank into the chamber *d*6 on the underside thereof, from whence the deposited salt is lifted by the endless chain elevator F and discharged down a shoot into a suitable receptacle. The mother liquor in the tank D in combination with the vacuum in the separator always maintains the level of such liquor in said tank corresponding to the vacuum in said separator. (*Accepted June* 25, 1919.)

TEXTILE MACHINERY.

129,249. W. Fielden, Blackburn. Shedding-Motion. (3 *Figs.*) June 6, 1919.—This invention relates to a shedding motion for looms. It consists in constructing an open shed dobby shedding motion with a number of oscillating or semi-rotary tappets or lifters fitted with transverse sliding bars or bolts held in position by pawls and operated successively by vertically-reciprocating knives carried in a reciprocating frame raised and lowered at each stroke of the loom. The apparatus is constructed with a number of oscillating or semi-rotary tappets A, one for each heald and pair of jack levers B, B. The tappets A are carried loosely on a central shaft C, upon which they are free to rock first in one direction and then in the other. The ends *b* of the jack levers B, B, bear against the external face of the tappets A, which are of such a shape or contour as when rocked in one direction will lift the pair of jacks B, B, and when rocked in the reverse direction (into the position shown) will lower the pair of jacks B, B. The jack levers B, B, are of bell crank shape and each pair is set one at either side of the tappet A,



fulcrummed above the centre, and with the short member bearing against the periphery of the tappet, preferably diametrically opposite one another, thereby balancing the weight of the healds and tension of the yarn and springs on the tappet, and reducing the strain or weight on the working parts. Each tappet A has a transverse radially sliding bar D capable of sliding from one side to the other by gravity as the tappet is rocked. The bar D is made with two projections *d* which extend outwards into the path of vertically reciprocating knife bars E when tilted, and is held in central or neutral position by pawls *d*1, *d*2, which are released by the pegs *f* on the lag barrel F. Each tappet A is also provided with a tooth-shaped projection *a*1 on its upper side, by which it is locked in position after each lift. The reciprocating knife bars E are carried in a vertically-reciprocating frame E1 raised and lowered from a crank on a revolving shaft of the loom. The knife bars E extend from one side to the other of the shedding motion and pass through apertures *a*5 in each of the oscillating tappets A. (*Accepted July* 16, 1919.)